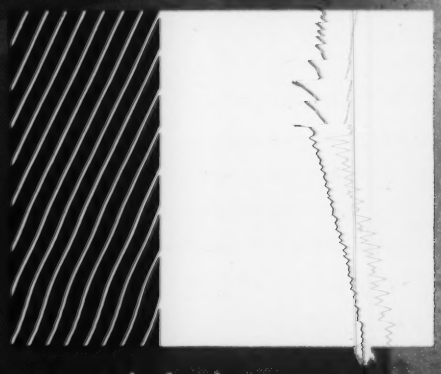
MAY 31, 1956
EVERY OTHER THURSDAY

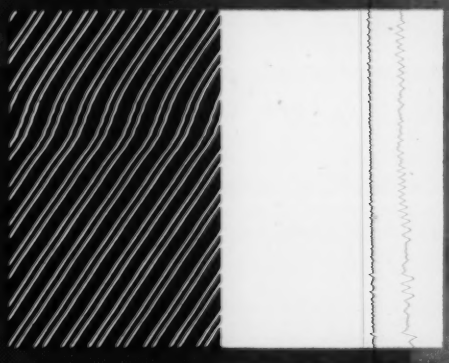
MACHINE DESIGN

A PENTON PUBLICATION

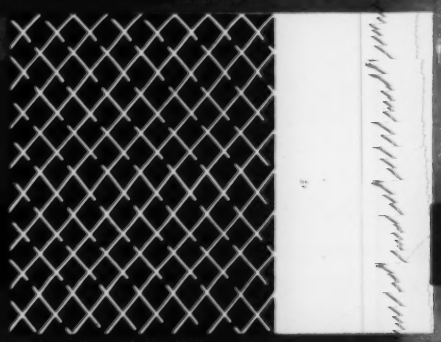
• electrical insulating materials • packing and gasket materials • materials for high



materials • corrosion-resistant structural materials • metals for low temperatures •

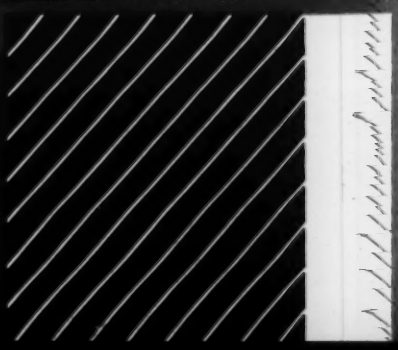


• spring alloys • materials for wear resistance • high-strength adhesives • metals



Engineering Materials

• sleeve bearing materials • packing and gasket materials • light alloys • materi



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Advantages

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- **Are compact, light in weight**
- **Allow greater freedom in design. In many cases these bearings provide the only solution where space is at a premium**

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GOODYEAR INDUSTRIAL PRODUCTS
GTM-Specified
Torsional rubber spring for Truck and Tractor Seats
1. Special, tough rubber compound to withstand constant torque
2. Strong rubber-to-metal bonds
3. Top Plate Assembly
4. Base Plate Assembly
5. Flanged Bearing

G.T.M. helps give "passenger car" ride to trucks and tractors

A "PASSENGER CAR" ride from trucks and tractors is now possible with a new type of seat which embodies a unique suspension system.

Heart of this system is a set of torsional rubber springs developed with the close help of the G.T.M. —Goodyear Technical Man. These husky cylinders of rubber are especially compounded and precision-molded, then mounted under torsion to level out vibrations *five times as effectively* as conventional springs. Moreover, they have proved to be unaffected by climatic changes and *as durable as the vehicles on which they are installed.*

The G.T.M. was consulted on this particular problem because of his broad experience in getting the most out of molded rubber in virtually any industrial application. Whether your problem involves torsional rubber springs or engine mounts or gaskets or rolls or bumpers or diaphragms or something completely new, you'll find it pays to talk to the G.T.M. It's easily done by writing Goodyear, Industrial Products Division, St. Marys, Ohio, or Akron 16, Ohio.

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THE GREATEST NAME IN RUBBER

IT'S SMART TO DO BUSINESS *with your Goodyear Distributor. He can give you fast, dependable service on Hose, V-Belts, Flat Belts and many other industrial rubber and nonrubber supplies. Look for him in the Yellow Pages under "Rubber Goods" or "Rubber Products."*

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

May 31, 1956
Volume 28—No. 11

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Subscriptions in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $20. Published every other Thursday and copyrighted 1956 by Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

When requesting changes of address, etc., please allow four to six weeks for processing.

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Getting more service hours per dollar

HOW TO SPECIFY FLEXIBLE METAL HOSE

3 simple steps can help you select metal hose for best results and longer service life

The important job of selecting the *most economical,* the *one right* flexible metal hose for your product or transfer problem can be greatly simplified by following these 3 steps:

1 Send exact specifications

Complete and exact statement of operating conditions will go far in saving you money on flexible metal hose.

First, it assures you that the connector you get will live up to your expectations. And, second, that manufacturers won't bid on hose that's "over-engineered." You'll save in the long run because you'll get the right assembly for every job.

Here is the information we need before we can give you our best suggestions:

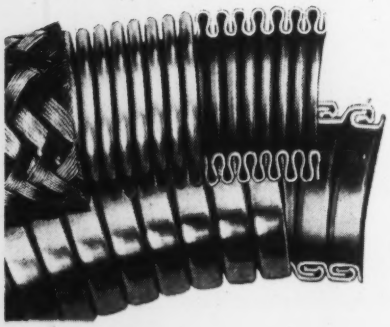
A PHYSICAL REQUIREMENTS:

1) *Over-all length (including fittings)*
2) *Diameter (I.D. and O.D.)*
3) *Fittings—size, type, style of thread*
4) *Tolerances permitted*
5) *Quantity required*

B OPERATING REQUIREMENTS:

1) *Material to be conveyed*
2) *Operating pressures—is there shock?*
3) *Operating temperatures*
4) *Movement—lateral and longitudinal*
5) *Vibration conditions?*
6) *Expansion and contraction requirements?*
7) *Corrosive atmosphere?*

Send sketch of proposed installation if available.



BASIC TYPES

CORRUGATED and STRIP-WOUND. In a wide range of sizes and styles in any workable metal. Various fittings.

2 Use standard metal hose where possible

Many standard connectors have been developed to meet problems common to many finished products—i.e., vibration. Often a standard metal hose will answer your needs as well as a special item could. We can often save you money if we know operating requirements.

3 Call the Man from Anaconda to help you select, specify, test

When selecting or specifying flexible metal hose, you'll find American's staff of trained engineers of invaluable assistance. Their advice and suggestions may help you solve or avoid many costly problems.

NEW INFORMATION

American Flexible Metal Hose and Tubing Catalog puts all the information you are looking for—both technical and general at your fingertips. Get your copy today, free of charge. Mail coupon below. 56177

WHEREVER CONNECTORS MUST MOVE

AMERICAN

FLEXIBLE METAL HOSE AND TUBING

an **ANACONDA** product

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me your free Quick Reference Catalog CC-400 containing basic information on all types of metal hose and tubing, fittings, etc.

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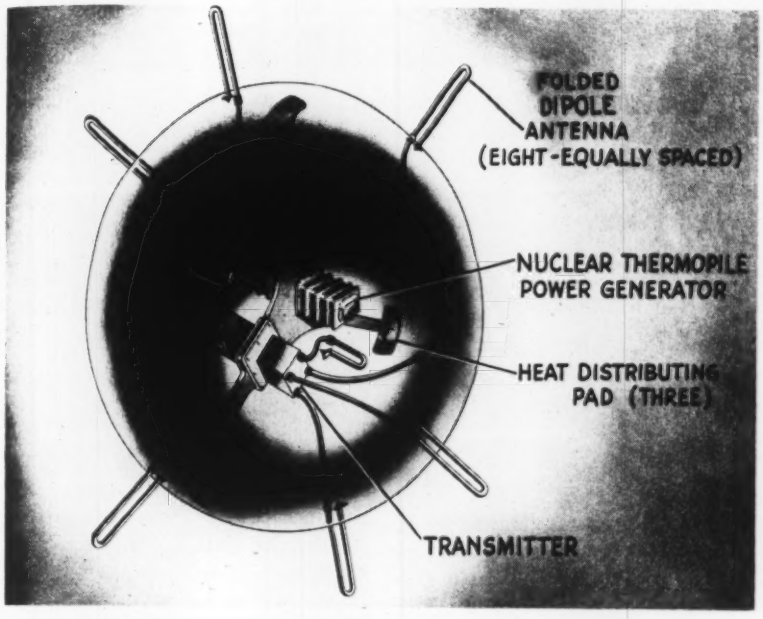
—ITEM 556—
For More Information Circle Item Number on Yellow Card—page 19

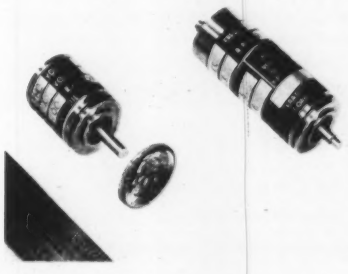
Engineering News Roundup



EARTH-SATELLITE NAVIGATION AID, called Astro, is conceived by Chrysler Corp. Missile Operations. This vehicle would be about 2 ft in diameter; follow an orbit 600 miles from earth; travel 276 miles per minute. Eight antennae on Astro would transmit a radio signal from a power source of 1 lb of strontium-90 combined with an yterrium isotope. Three Astros would be fired into space 8 hrs apart to provide a signal at any point on earth every 105 minutes. Astro almanac would be key to the navigation system.

Produce Smallest Servomotor and Generator

Dime-Size Units For Standard Voltages



WORCESTER, PA.—A ¾-in. diam servomotor and motor-driven induction generator are announced by the Transicoil Corp. as the smallest ever produced for practical application. Despite their small size, the units can be wound for standard voltages and push-pull application.

These units exhibit characteristics comparable to those which were previously the smallest available, but are 40 per cent lighter in weight and 10 per cent smaller in diameter. In keeping with the miniature size, an all-transistor amplifier has been developed to power the servo combination.

The control motor operates on 26 to 52 v, 400 cycles at a free speed of 7600 rpm and has a stall torque of 0.20-oz-in. Power output is 0.293-w. The generator delivers 0.3 v at 1000 rpm. Power input is 1.8 w.

Conveyor System Is Magnetic Tape-Controlled

Automatic Warehousing Featured in AF Depots

ST. PAUL, MINN.—A magnetic tape-controlled conveyor system that automatically discharges packages in any desired sequence at from 2 to 20 stations has been installed at Air Force supply depots over the country. Called ASSET — Automatic Selected Station Electronic Timer — the tape-controlled units are claimed the first of their kind. They were developed and installed by the A. J. Bayer Co., Los Angeles, and use 35-mm magnetic film made by Minnesota Mining and Mfg. Co. Savings of time and money are claimed for ASSET units operated at seven Air Force bases.

The ASSET system is designed for use on transportation-discharge conveyors — for shunting off packages, cartons, boxes or crates from a main conveyor line to a series of branch conveyors.

A single operator at the loading end of the conveyor notes the type of goods contained in each package as it approaches, decides to which warehouse area it should go, and then pushes a selector button for the discharge point.

The moving package interrupts the beam of a photoelectric cell at the side of the conveyor near the operator. The magnetic tape memory automatically routes each package to the appropriate branch conveyor, centering each package on its conveyor and requiring no further attention from the operator.

The ASSET system is essentially a magnetic tape scale model of the actual conveyor layout. An endless loop of magnetic tape represents the endless belt-type conveyor. The conveyor and tape are

PERIOD PIECES recently presented to the Smithsonian Institution by the General Electric Co. are some of the first true diamonds made by man. Focal point of the Smithsonian exhibit is the cluster above, about 1/4 in. diameter, compared for size with a Rockwell hardness tester point. Simultaneous with the presentation, GE revealed limited production of diamonds in its Detroit pilot plant and steady progress in cost reduction. A $200-million annual business is foreseen in ten years.

synchronized, but the tape is geared down 6-to-1 from the conveyor speed of 48 fpm.

A package placed on the conveyor is represented by an impulse recorded on the tape. A branch conveyor a specific distance down the main conveyor is represented on the tape by a playback, or pick-up, head mounted a proportionate distance down the tape from the record head.

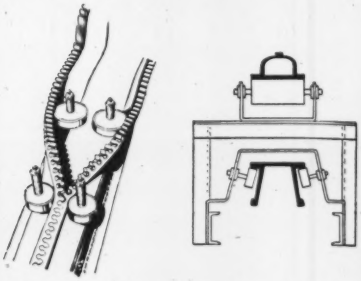
Ten recording heads can use one tape. If more than 10 stations are to be handled, a second or third tape layout is added to the panel providing for the additional discharge points.

Conveyors Prove Efficient In Handling Carbon Black

Zipper Type Rubber Belt Minimizes Dirt

TUSCALOOSA, ALA.—Carbon black, in the form of pellets, is carried to storage bins by a zipper belt conveyor in a new B. F. Goodrich installation. A similar method has been used successfully at the company's Akron plant.

The procedure employs a Stephens-Adamson zipper belt-conveyor-elevator that moves the carbon pellets without damaging their physical structure. Dirt usually associated with handling carbon black is kept to a minimum. The rubber belt closes to form a snug tube around the material and moves with it to the discharge point. It is zipped open at the storage tank and returns flat.



Zipper conveyor belt shown at opening or closing point, left, and in cross-section, right.

Two belts totalling almost 290 ft carry approximately 9 tons of carbon black an hour at the Tuscaloosa installation. The first belt follows a horizontal, vertical and inclined path to move the material to the top of a storage bin, about 80 ft above the ground. At that point the black can be discharged or chuted to a second belt that carries it to additional storage tanks.

Casts Threads Directly Into Gray Iron

Use of Inserts Eliminates Machining

BROCKTON, MASS.—A method of producing gray-iron castings with integral stainless-steel threads has been developed by Le Baron Foundry Co. The new process eliminates conventional drilling and tapping.

Cores are baked inside stainless-steel wire-thread inserts, the inserts are placed in the mold, and the casting is made. Blast clean-

Front Cover

The basic building blocks of design are engineering materials. As a theme for the front cover, artist George Farnsworth has used a building-block pattern of typical material cross sections combined with topics suggesting the articles in this Special Issue on Engineering Materials.

Facing Page—ITEM 557→

U.S. Army Photograph

Quick on the bull's-eye and stay there

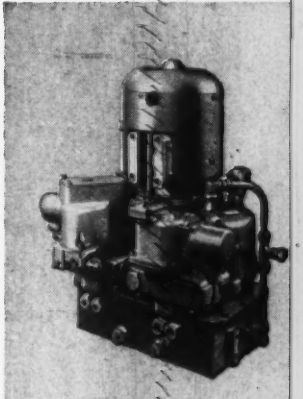
WITH OILGEAR FLUID POWER

Meeting speed, control and precise performance requirements of today's U. S. Tanks, Howitzers and Anti-Aircraft Guns is a "Natural" for Oilgear ANY-SPEED Fluid Power Components.

Gunners in Sherman, Pershing and Patton tanks experienced the advantages of rapid fluid power slewing and precise fluid power tracking of the turret and gun 360° in either direction. They appreciated the value of Oilgear fluid power that obeyed a light twist of the wrist. Likewise, those manning America's most effective 40 mm anti-aircraft guns, recognized the importance of automatic, self-synchronizing Oilgear fluid power drives for rapid slewing and precise tracking of the carriage 360° in either direction and the rapid, accurate elevating and depressing of the gun for quick homing on the target and following it.

Therefore, when today's new combat vehicles with far greater fire power and accuracy were planned, Oilgear ANY-SPEED Fluid Power Drives were a "Natural" for both turret traverse and gun elevation. They met the demands for accurate control over speed ranges up to 4000:1. They provided unbelievably low tracking speeds under precise response without overrun or drift. They stayed on the target for repetitive shots. No wonder, one men's magazine calls the new Oilgear equipped M47 "the sharpest shooting tank anywhere today." That's why Oilgear ANY-SPEED fluid power drives are a "Natural" on the wide variety of U. S. combat vehicles.

Don't you think it is time for you to look with wide open eyes at Oilgear Fluid Power Pumps, Motors and Transmissions for **your** machines... to better the performance of an already good machine? To solve a seemingly "impossible" design problem? To synchronize machine units easily and economically? To weed out trouble and cut maintenance and down time to a surprisingly low level? Counsel with an Oilgear Engineering Representative will cost you nothing, may benefit you greatly. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wisconsin.



OILGEAR POWER PACK

Self-contained unit used in present day tanks and howitzers. Consists of electric drive motor, two Oilgear two-way variable delivery pumps (or generators), oil reservoir and integral closed system controls for turret traverse and gun elevation. Supplies fluid power to Oilgear hydraulic drive motors.

OILGEAR

OILGEAR

ing removes the cores from inside the inserts, leaving the threads.

A special insert for this casting-in process was developed by Heli-Coil Corp. The coils are wound in tight contact with each other to prevent hot metal from penetrating to the inside of the insert, and to maintain correct thread pitch. The metal flows around the outside of the inserts to form a bond that approximates actual fusion.

PLAQUE FOR THE BEST SINGLE ARTICLE entered in the industrial publications division of the 18th Annual Business Paper Editorial Achievement Competition was awarded to *Machine Design* for "When to Specify Special Motors." This article appeared in the November, 1955, issue. MD also won a certificate of merit for the best series of articles, the series on "Adjustable-Speed Drives," which appeared in the October 1954, issue and the April, June and October, 1955, issues.

New Lubes for Aircraft Will Take the Heat

For Use With Metals That Work At 2000 F

LOS ANGELES, CALIF. — General Electric laboratories claim to be "on the doorstep" of finding high-temperature aircraft lubricants that will operate between 1000 and 2000 F. The absence of a lubricant with this property has been said the most critical bottleneck in developing planes to exceed present speed records.

Announcing the development, Dr. Donald F. Wilcock of GE said "we have metals that will function up to 2000 degrees F but we've never had a fluid lubricant that would keep pace. Today the upper limit is around 500 degrees in aircraft hydraulic systems and around 350 in bearings. Silicone fluids can take up to 600 degrees, or at the most 700."

The new compounds, it is said, will flow at red heat and will open up new horizons in aircraft engine design. They will apply to both hydraulic systems and bearing systems.

"Some of these compounds," Dr. Wilcock said, "have such a fantastically high boiling point that they will actually freeze at temperatures around 400 degrees. This is all the more incredible when you consider that this is in the range where some present lubricants boil. The challenge to the struc-

Topics

Testing a vertically positioned jet engine has been accomplished in Ryan Aeronautical Company's new jet test cell. The test unit, designed primarily for development of vertical take-off and landing projects, has facilities for both vertical and horizontal operation of jet engines.

• • •

Automatic machinery tells New York subway riders where to get off. A machine in the Times Square station produces—a few seconds after the correct button is pressed—a slip of paper with printed directions for reaching any other subway station, theaters, restaurants, department stores, points of interest and special events.

• • •

Gasoline blended at the pump to suit high or low octane rating requirements is offered by Sun Oil Co. in its Florida service stations. Regular gasoline and a concentrate are mixed in proportions determined by a dial setting on the pump to produce one of five grades of fuel.

• • •

New member of ASME, President Eisenhower recently accepted an honorary membership in the society.

• • •

Models of super high-speed missiles will be tested by being shot from a gun that can fire objects the size of golf balls at a speed of almost 7000 mph. A working model of the 16-ft long, 40-mm gun is now at the Naval Ordnance Laboratory, and the gun itself is under test at Dahlgren Proving Grounds.

• • •

A member of the Joint Atomic Energy Committee is quoted as saying that the United States is "on the threshold" of producing an atomic-powered plane that can circle the globe without refueling. Stepping over the threshold into an "economical" atomic plane will take from two to five years, he believes.

• • •

They sure don't build 'em like they used to. The average lifetime of motor vehicles has doubled since 1930. Cars and trucks now average 13.8 years of useful service, and average mileage is 122,000.

Facing Page—ITEM 558→

New COMPO E®

BEARING MATERIAL

SAVES UP TO 40% ON BEARING COSTS • COMBINES THE ADVANTAGES OF BOTH BRONZE & IRON • SUPPLIES "BUILT-IN" LUBRICATION OF 23% BY VOLUME • INSTALLS AS EASILY AS HIGHER-PRICED BRONZE BEARINGS • OPERATES AT SHAFT SPEEDS UP TO 3500 RPM • AN

EXCLUSIVE BOUND BROOK MATERIAL

BACKED BY 73 YEARS' EXPERIENCE

write today for complete data

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

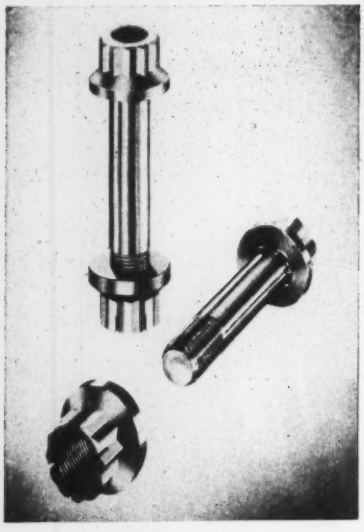
POWDER METALLURGY BEARINGS + PARTS

tural organic chemist is to design these stable high-boiling molecules so that they will be fluid at lower temperatures, and so that they will have the 'oiliness' characteristic necessary for many vital applications."

Super Bolts of Steel Have New High Tensile Limit

Even Tougher Aircraft Fasteners to Come

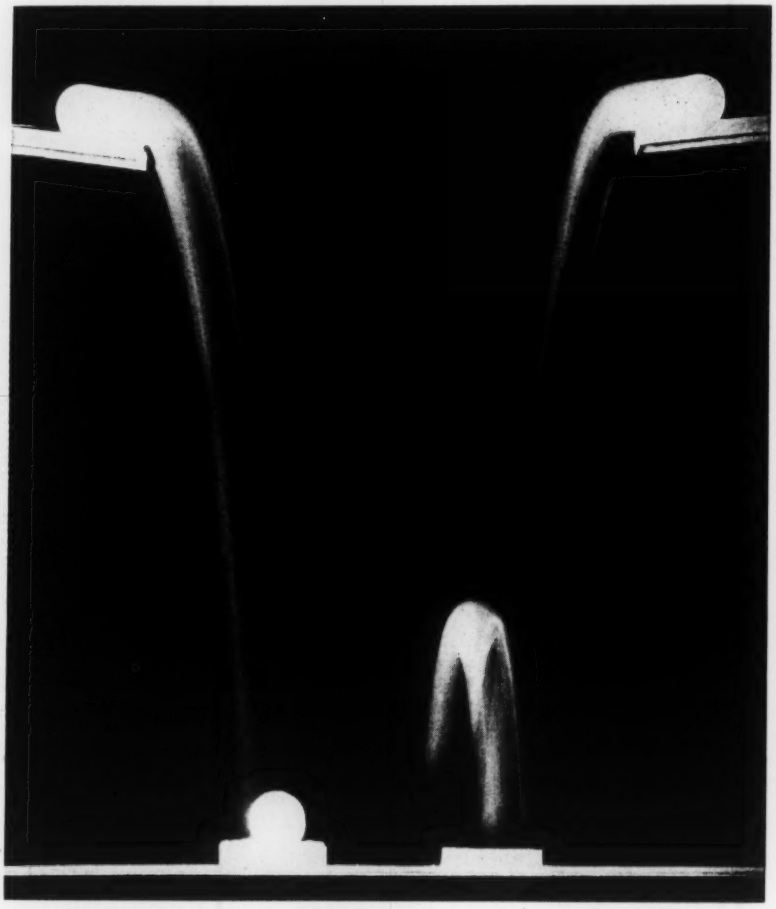
JENKINTOWN, PA. — New steel bolts with tensile strength from 220,000 to 240,000 psi have been announced recently by the Standard Pressed Steel Co. Designated EWB-22, the new bolts have broad applications, but were made primarily for aircraft. Their strength is said to be the highest yet attained in a threaded fastener—



about 40 per cent greater than that of the best aircraft standards (MS-20004 series) now used.

The bolts also have a minimum shear strength of 130,000 psi as compared to 95,000 psi for current aircraft shear bolts. Fatigue strength is also improved—78 per cent greater than present aircraft standards. Further development by Standard Pressed Steel is aimed at a tensile limit of 300,000 psi.

Other components of fastener assemblies using the new bolts are automatic preload-indicating washers, and high-strength external-wrenching locknuts.



ATOM BULLETS MAKE BOUNCY GUM is the recent discovery of Westinghouse researchers. Their process uses 2-million-volt electrons to convert silicone gum into silicone rubber in 2 seconds where conventional vulcanizing methods take several hours. Westinghouse says the process duplicates the good features of chemical vulcanization but is not ready for commercial use

Navy Finds Pump and Hose Best for Fueling Aircraft

Air-to-Air Refueling Methods Systemized

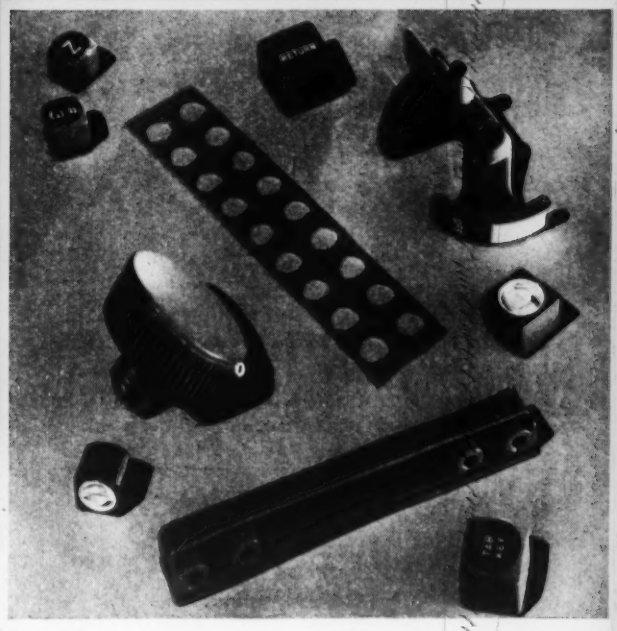
WASHINGTON, D. C. — Aerial in-flight refueling has become the Navy's current answer to extending the range of carrier-based jet planes. With many satisfactory tests under different conditions completed, the Navy has decided on three basic types of tankers, and it favors the pump and hose rather than the rigid tube method of fuel transfer.

The three basic tanker types are the (1) Strike Tanker, (2) Sustaining Tanker, and (3) the Large Tanker.

The Strike Tanker is used for the primary purpose of range extension on attack missions. Included in this category is the "Buddy" tanker which involves the conversion of a jet fighter or attack aircraft. The striking plane and its buddy tanker, the same model airplane, are launched together and proceed toward the target. Over half way, the tanker transfers part of its fuel to the other plane. The tanker then returns to the ship while the strike aircraft continues to the target.

The carrier-based Sustaining Tanker is used to extend the endurance of defensive aircraft and to refuel aircraft in emergency situations. This tanker is readily convertible by installation of an air refueling package. Should a curtain of fog drop over an aircraft carrier while its planes are airborne, it would be possible to

Facing Page—ITEM 559→



Parts molded of C-11 Plastics for
International Business Machines Corp., New York 22. N. Y.

Why IBM chose C-11 plastics *for electric typewriter*

key buttons, platen knobs, space bars, and switch levers

Typewriter parts that are most on view get the most abuse. But they never show it on this new electric typewriter. Buttons, keys, switches, and bars are all molded of BAKELITE Brand C-11 Plastic, a styrene-acrylonitrile copolymer.

C-11 replaced older materials because it resists staining by ink, oil, carbon paper, and cleaning fluid. It withstands abrasion by operators' fingernails.

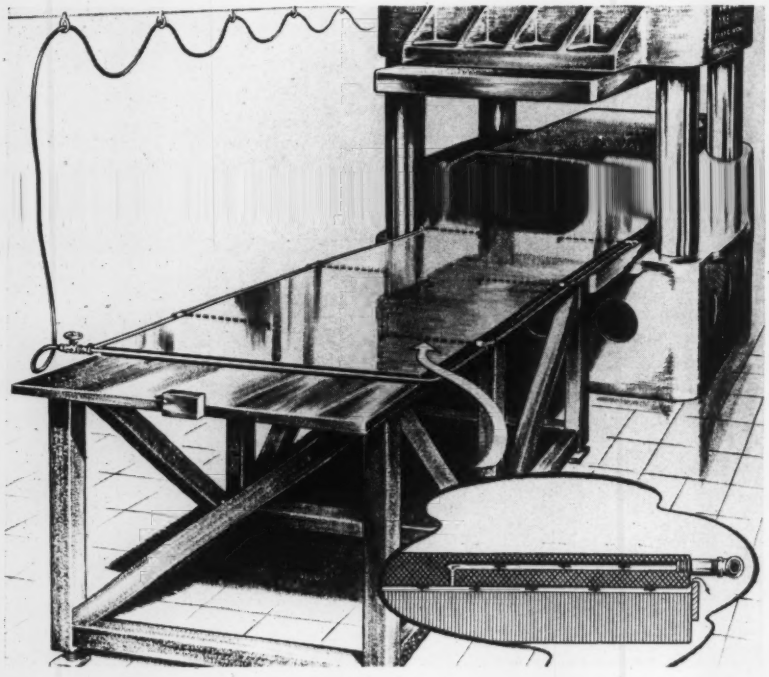
BAKELITE C-11 Plastic produces parts that are formed with a high degree of uniformity and accuracy and do not warp or swell. The white characters on the keys illustrate this feature. The outer block of gray C-11 is molded hollow, with the character opening through to the top. An insert of white C-11 is molded into it from the under side, and formed with a slot to fit the key arm. Notice the clean details of this two-shot molding.

BAKELITE C-11 Plastics have the combination of molding accuracy, toughness, eye-appeal, and chemical resistance that you may want for your product or part. To learn more, write Dept. PN-103.

BAKELITE
BRAND
C-11 PLASTICS

See BAKELITE'S exhibit, booths #809, 813, 817, 825, National Plastics Exposition, June 11-15, 1956, New York Coliseum, New York

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC



STEEL SLABS FLOAT ON AIR in the heavy press department of Northrop Aircraft. Tool engineers have employed pneumatic principles to move a transfer plate and die with combined weight of 1000 lb. Six evenly spaced 1/8-in. holes inject air at 100 psi against a hydraulic press table to lift the tooling plate. Operators then move the die under the press easily.

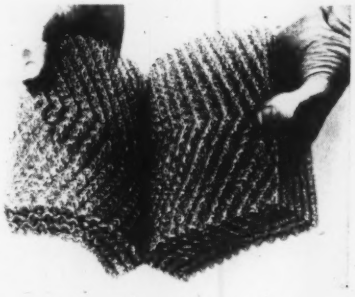
refuel the thirsty jet aircraft from the Sustaining Tanker.

The large Tanker, presently the Convair R3Y Tradewinds, affords the ability to exploit all the uses of air refueling. It can refuel as many as four fighter aircraft at the same time and can deliver huge quantities of fuel over great distances.

Mesh Mist Eliminator Has Herringbone Pattern

ROSELLE, N. J.—A new type of wire mesh entrainment separator, knitted from Monel nickel-copper alloy wire for use in corrosive environments, has been developed by the Metal Textile Corp. The wires are folded in a herringbone pattern thereby exposing more area for impingement than other designs.

The improved mesh, designated "Hi-Thruput Herringboned Mist Eliminator", is said to be economical in drying gaseous streams and more efficient in preventing valuable or troublesome products from going up the stack.



After herring-boning, the wires of the mesh touch only on the top of the crimps in each ply. Large areas of wire surface are free and usable for impingement.

High temperature symposium, entitled "High Temperature — A Tool for the Future," will be held June 25, 26 and 27 on the Berkeley campus of the University of California. The symposium's three sessions will be devoted to methods of reaching high temperatures, materials for use at high temperatures and processes involved in the uses of high temperatures. Sponsors are Stanford Research Institute and the University of California.

Adopt New Standard For Reinforced Plastics

Covers Glass-Mat Laminate

NEW YORK, N. Y.—A new standard reinforced-plastic sheet laminate for mechanical and electrical applications has been adopted. The standard covers a general-purpose grade of polyester glass-mat sheet laminates. Sponsoring organizations are National Electrical Manufacturers Association, the American Society for Testing Materials and the Society of the Plastics Industry Inc.

Increasing use of this new high-impact sheet material by electrical equipment manufacturers led to the formation of special committees in each of these organizations to study industry's needs and to create uniform standards.

The new standard specifies control values for essential physical and electrical properties for a glass-mat reinforced polyester plastic sheet laminate intended for use at elevated temperatures as required of Class B electrical insulation. It covers only the most essential and most easily measured properties. More items may be added to the controlling standards as more information becomes available.

Inventors Council Poses Current Problems

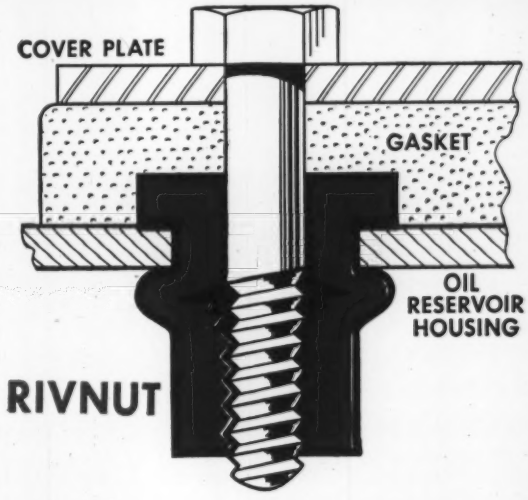
Materials and Devices Needed by Armed Forces

WASHINGTON, D. C.—The National Inventors Council, created in 1940, has periodically issued lists of problems to which the Armed Forces are seeking solutions. The current list, like its predecessors, is intended to stimulate creative thinking along lines beneficial to the nation's defense effort.

The problems are of two general kinds: (1) descriptions of general areas in which technological advances are desired, and (2) specific problems. For the second type, Inventors Council may be able to supply information beyond the statement of the problem if

B.F.Goodrich RIVNUTS

save time, cut costs by eliminating welding, tapping, cleaning



OLD WAY

1 Weld 4 nut plates to inside of housing
2 Drill
3 Tap
4 Clean
5 Attach cover with bolts

WITH RIVNUTS

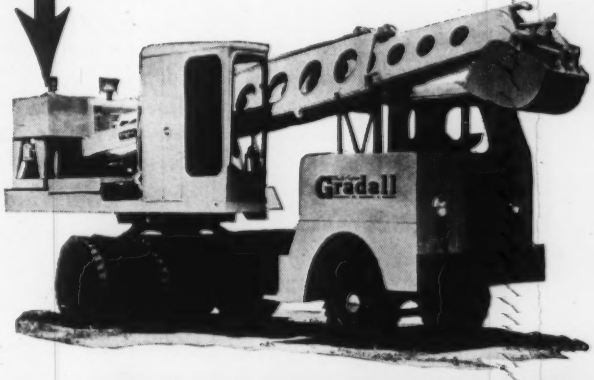
1 Punch holes in housing
2 Insert Rivnuts and upset
3 Attach cover with bolts

B. F. GOODRICH RIVNUTS cut costs and speed assembly by providing a firm, accurate nutplate in one operation!

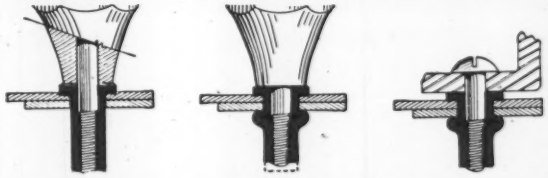
This fastening job on Warner & Swasey's Multi-Purpose Gradall used to take five operations. Oil reservoir housings had to be detoured from the assembly line to weld four nutplates on the inside. Then they were drilled, tapped and cleaned before the cover could be attached. By switching to Rivnuts, welding, tapping and cleaning were eliminated.

Now one worker installs Rivnuts from one side in seconds. Assembly flow is straightline. Fastening time is cut in half.

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs and eliminated costly steps. They can do the same for you. Get more information or engineering help by writing: *Rivnut Sales, B. F. Goodrich Tire & Equipment Company, a Division of The B. F. Goodrich Company, Akron, Ohio.*



HOW RIVNUTS PROVIDE AT LEAST 6 CLEAN THREADS IN ONE SIMPLE OPERATION:



1 Rivnut is threaded onto pull-up stud of heading tool, then inserted.

2 Tool lever operates pull-up stud forming a bulge in the Rivnut shank.

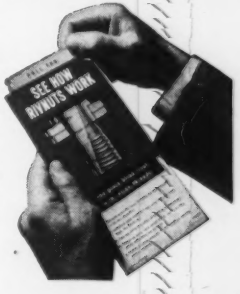
3 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

RIVNUT

THE ONLY ONE-PIECE BLIND RIVET WITH THREADS

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

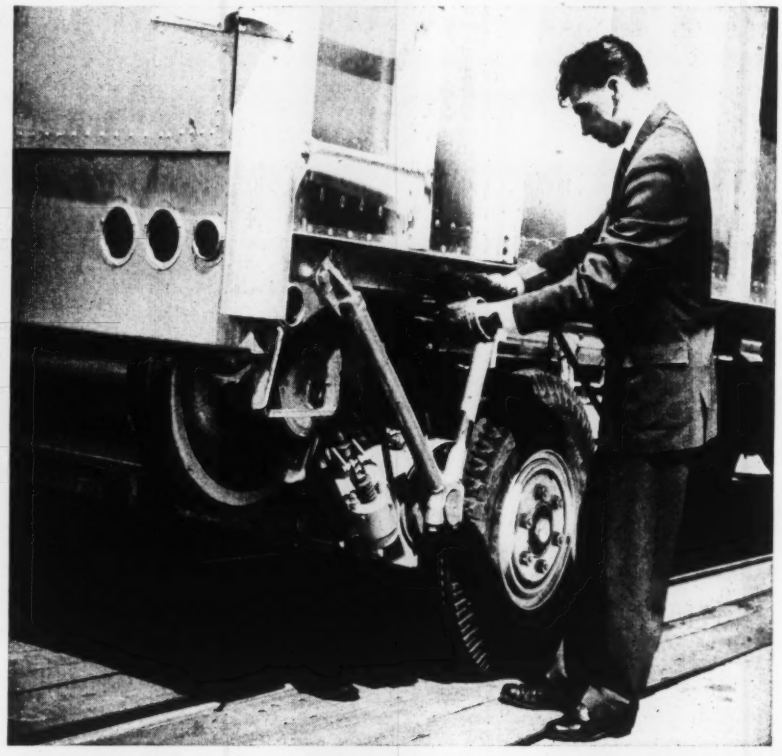
Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy by writing to: The B. F. Goodrich Co., Dept. MD-5B, Akron, Ohio.



details needed are specified. For the first type, inventors are on their own.

Anyone may submit proposals in any form, but the Council advises that proposals should be typed and copies retained. Correspondence should be addressed: The National Inventors Council, U. S. Dept. of Commerce, Washington 25, D. C.

Copies of the current problem list can be obtained from the Council or Dept. of Commerce Field Offices.



Compressed air motor on Chesapeake and Ohio "Railvan" raises and lowers either truck wheels or rail wheels when changes of operation occur at terminals and transfer points.

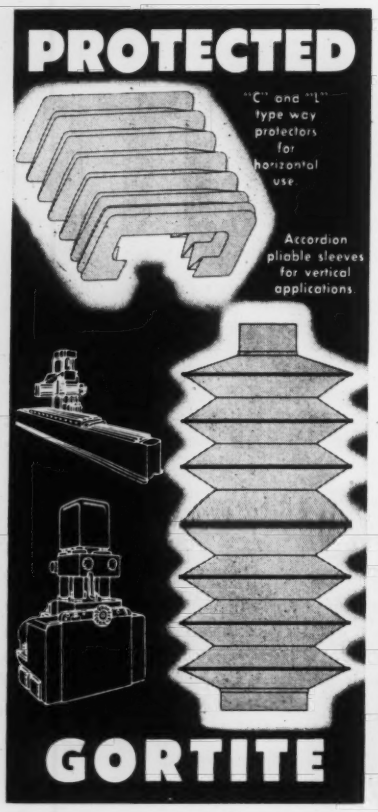
Truck-Train Van Cuts Freight Time and Cost

Wheels Ride Both Rails And Roads

CLEVELAND, O.—To help solve twin problems of cost and time in moving freight, the Chesapeake and Ohio Railway has built a new versatile vehicle, the Railvan.

The new carrier combines the features of a truck trailer and railroad box car. Its trailing end carries both railroad wheels and truck tires. To change from road to rail operation, the wheels are raised or lowered by a compressed air motor installed in each van. Railvans would be made into trains and would also be hauled individually behind truck tractors. Changing operations at terminals does not involve handling equipment other

With highway wheels down, Railvan leaves terminal behind conventional truck tractor.


PROTECTED
"C" and "L" type way protectors for horizontal use.
Accordion pliable sleeves for vertical applications.
GORTITE

1 or 1000

without mold charge!

ALL SHAPES AND CONTOURS

Many shapes and contours, like these shown here, are described in a NEW bulletin SPC-2: Zippers and special, duPont coatings extend the range of usefulness for dirt exclusion and lubricant retention. Fabricated from duPont (neoprene-base) materials GORTITE parts last from 3 to 5 times longer than molded rubber. For bulletins, layouts, designs and estimates write or wire to—

A&A Mfg. Company Inc.
2017 W. Cirbourn St. • Milwaukee 3, Wis.

—ITEM 561—

than a truck tractor.

A key feature of Railvan is the wheel suspension. Arms supporting both the highway wheels and the rail wheels are attached at the outer casing of a Goodrich Torsilastic spring. The spring consists of a rubber tube vulcanized to an inner stationary tube and outer sleeve, providing elasticity through deflection of the rubber. By hinging the highway arm on the spring, the rail wheels can provide the necessary clearance between the rail and the tires.

Transistor-Equipped Switchboard Made for Navy

ROCHESTER, N. Y.—A transistorized all-electronic dial telephone switchboard which uses no vacuum tubes or mechanical stepping switches has been developed by Stromberg-Carlson for the Navy.

In this switchboard, all line finding, circuit switching, tone signal generating, and other functions of conventional dial systems, are performed by transistors or diodes. These parts are all germanium junction type. This is the first such complete transistorized switchboard publicly announced in this country.

The transistorized switchboard is said to have a number of advantages over conventional electromechanical switching systems. It is compact, and lightweight, requiring less than half as much space as existing systems. It weighs about one-quarter as much as a typical electromechanical dial system. These factors are especially important in shipboard installations, where space and weight must be kept to a minimum.

Since the switching is done electronically, the absence of moving parts eliminates problems caused by dust, wear, corrosion and other similar factors which affect electromechanical systems. If desired, transistorized switching systems can be completely sealed, or component subassemblies can be sealed in plug-in units.

The transistorized system is expected to be virtually maintenance-

(Continued on Page 22)

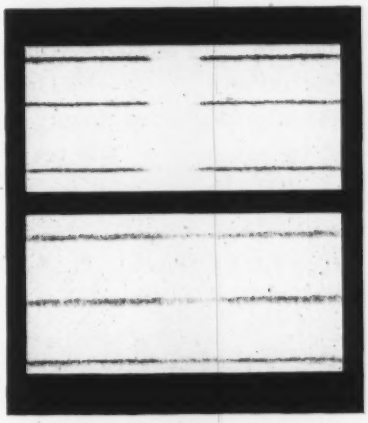
DRAFTING TRENDS

Controlled tests have proved the remarkable erasing qualities of new Blutex tracing vellum.

Improved tracing vellum erases cleaner and faster

A newly improved vellum called *Blutex* has unusual erasing qualities and eliminates "ghosting" on tracings and prints. Manufactured by Post, the product is a revised formulation of an established vellum.

Chief reason for the cleaner erasing qualities is a new combination of transparentizing materials used in treating the base stock. (The base stock itself is exceptionally hard.) Unlike many other vellums, *Blutex* is



Unretouched photos of pencil lines and erasures on Blutex (top) and another leading vellum after identical aging of both sheets.

treated with 100% synthetic resins rather than oils. The carefully selected resins provide a "drier" working surface; dry yet never brittle. This unusual dryness, combined with an extra hard surface, permits faster, cleaner erasures.

The new process also affects the *future* erasability. The materials are specifically formulated to resist heat and aging. The transparentizing agents will not *fuse* with the graphite lines, a common condition in other vellums that make erasures difficult. Laboratory tests have shown that *Blutex* is just as erasable after 100 trips through a printer as it is when first used.

Another Blutex advantage is its fine *drawing* quality. The dry surface and excellent tooth take dense, opaque lines with ease and uniformity.

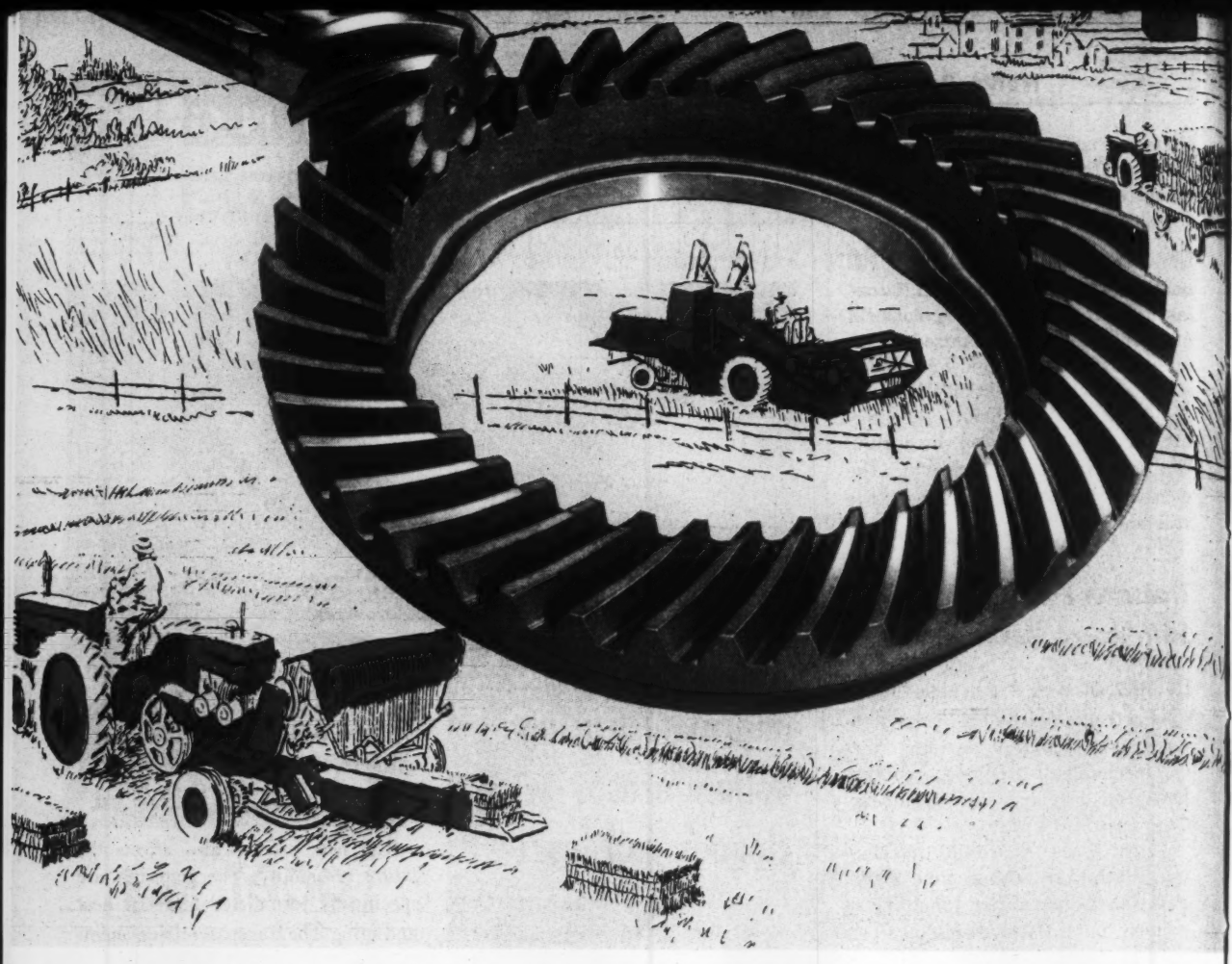
In addition to these improvements, new *Blutex* is actually more transparent. The new formulation is carefully controlled to preserve the stock while actually increasing the transparency.

Testing samples and information on Blutex is available from the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

—ITEM 562— Facing Page—ITEM 563→



AGRICULTURE-geared to modern production standards

Unlike industrial machinery, farm equipment is exposed to everything that nature can throw at it. Soil is the element in which farm machines work. They're exposed to every fury in the book — heat, cold, snow, ice, dust. They stand idle much of the time, then go to work at an instant's notice, performing perfectly for hundreds of gruelling hours. And they must be built against breakdown that interferes with the critical time schedules of much farm work.

That gears of our manufacture are specified for so many different kinds and makes of farm machinery is proof of their rugged ability to perform reliably under the most rigorous circumstances. Their daily work on America's farms proves their fitness for service in your products or equipment.

Why not write today for further information?

DOUBLE DIAMOND TRADE MARK GEARS

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914 RICHMOND, INDIANA

SUBSIDIARY OF EATON MANUFACTURING COMPANY

Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MAY 31, 1956

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418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
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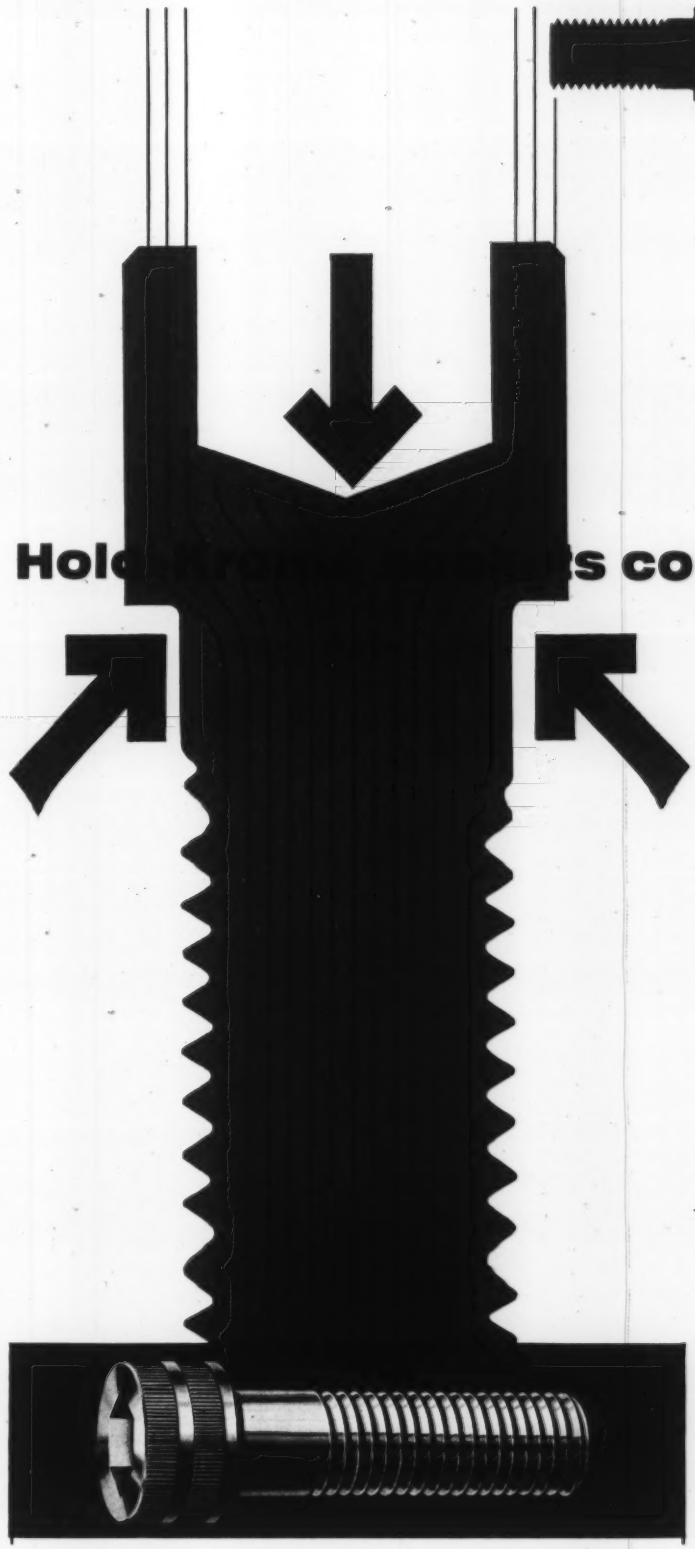


INSIDE INFO FROM HOLO-KROME

THE SECRET'S IN THE SOCKET!

Since 1932, H-K has completely forged socket screws for greater strength where needed. Originally developed by Holo-Krome, cold-forming maintains metal fibers intact for greater strength. No drilling or broaching to weaken an H-K socket wall. You get tougher screws when they're H-K's!

Holo[illegible]s completely forged!

Compare These Other H-K Features!

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

UNTAPERED WALLS . . . for better key fit, longer key and socket life, even tighter wrenching.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

NAME _____

POSITION _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

HOLO-KROME

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN.

Sold only through authorized Holo-Krome distributors.

Each part of every Curtis Universal Joint is made of specially selected steel, individually heat-treated for a specific purpose. This care in manufacture is reflected in our catalog torque and load ratings — which are substantiated by constant testing of production joints.

That's why Curtis Joints are the most dependable, durable and trouble-free available—the standard of the industry.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock — bored or unbored hubs
- Fewer parts, simpler construction
- Complete equipment for government tests

PLUS — facilities and engineering skill to handle special specification jobs at any time.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

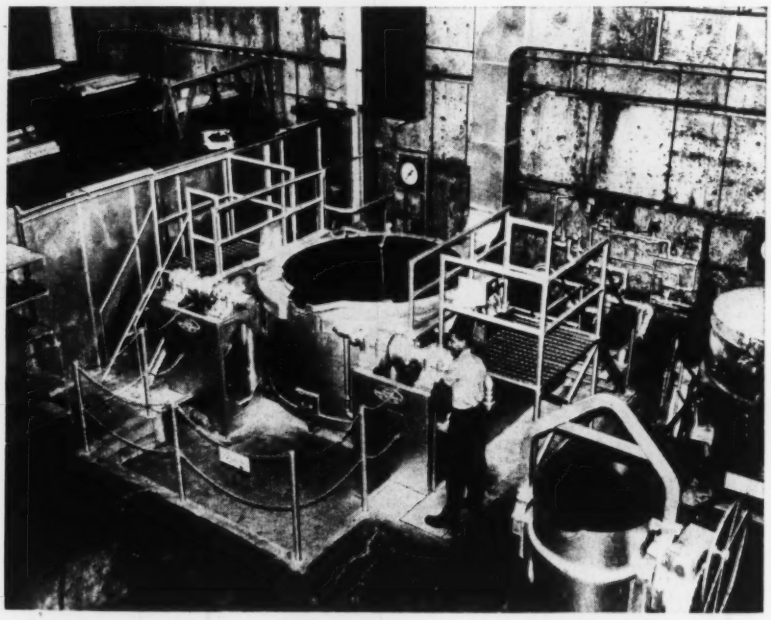
5 BIRNIE AVENUE, SPRINGFIELD, MASS.

As near to you as your telephone

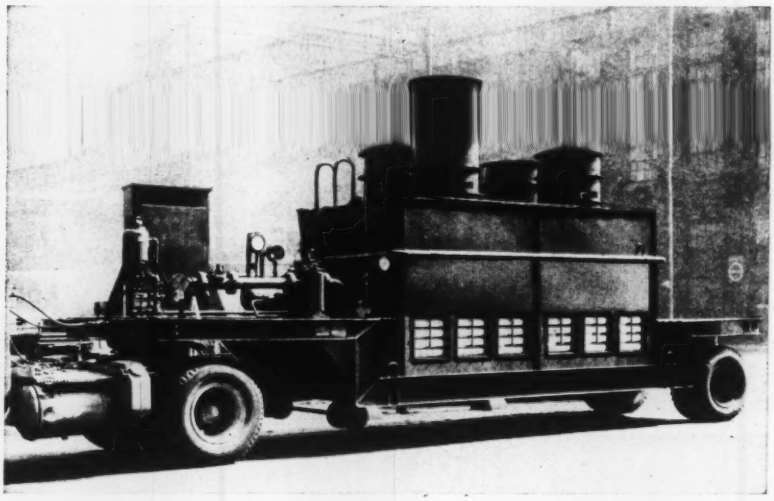
A MANUFACTURER OF
UNIVERSAL JOINTS SINCE 1919

—ITEM 565—

Engineering News Roundup



CUT-UP TIME IS SAVED by this big melting furnace built for a California aircraft company by Belleview Industrial Furnace Co. The nose-tilting pot has 76-in. diameter and 37-in. depth; holds 25,000 lbs of Kirksite scrap dies which need not be cut up before remelting. The furnace has processed 200,000 lb of obsolete dies in four days. Savings claimed in the use of remelted Kirksite die metal are 6½ cents per lb over the cost of new ingots.



WATER WAGON for thirsty plants is this portable cooling tower developed recently by Badger Mfg. Co. Compact and complete, the truck-mounted unit includes pumps, strainers, electrical control equipment, gages, thermometers and feed water conditioner. When operating at 95 F air temperature, and 90 F wet bulb temperature, the system delivers 240 gpm at 90 F reduced from 115 F. It is presently being used with portable oxygen-generating plants in remote locations, and could be used in chemical plants.

(*Continued from Page* 15)

free because the transistors are rugged and have theoretically infinite operating life. The transistors generate practically no heat, and can operate at temperatures of 130 F or above. The new switchboard has been designed and built for compatibility with other U.S. telephone equipment.

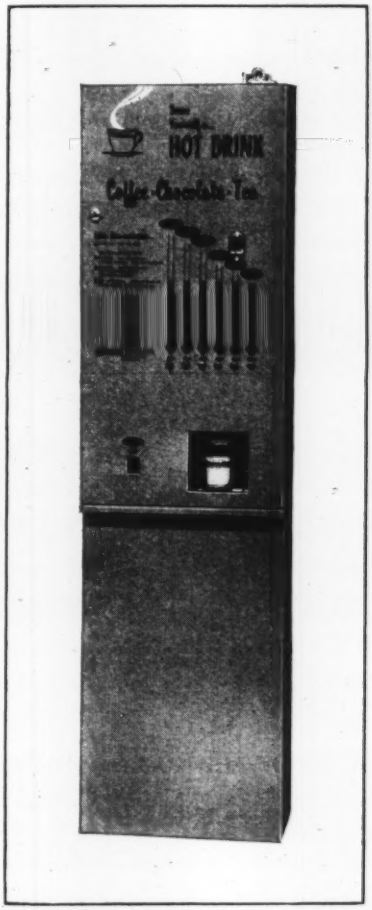
The Gray Iron Founders' Society announces that entries are being accepted for the 1956 Gray Iron

How to Keep Drinks Hot

No. 6 of a series — *Showing the Broad Application Range of Fenwal Controls*

You need hot water for good coffee, tea or hot chocolate. And the Fenwal Thermoswitch Control makes sure this machine always has water at the right temperature. Here's how.

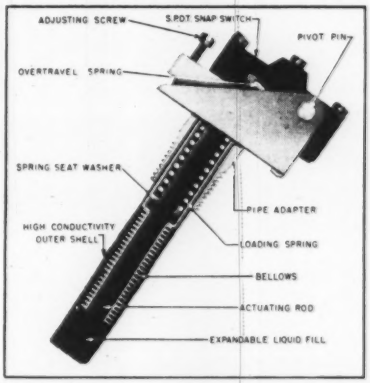
A Fenwal Snap-Action THERMOSWITCH unit, No. 20102, skeleton frame immersion type, with a standard snap-action switch "S", 100-300°F range, controls a 1400 watt 110 Volt AC heater in a half gallon hot water tank. The THERMOSWITCH is preset at 160°F ±5°F, and is mounted vertically in top of tank. The heater is mounted from the bottom of tank. (Another Fenwal THERMOSWITCH unit, the series 30000, controls the internal cabinet temperature.)



FENWAL THERMOSWITCH® unit, series 20000, is installed in this Superior Hot Drink Bar, manufactured by the Superior Manufacturing Corporation of Denver, Colorado.

How Fenwal Thermoswitch® Series 20000 Operates

The Fenwal Snap-Action THERMOSWITCH unit provides fast response because the fluid completely surrounds the bellows and is in direct contact with the external shell. The contacts in the head of the unit are actuated by a push-rod connected to the bellows. Units are available in six UL listed temperature ranges: Series 20000: −75°F to 125°F; 25°F to 225°F; 100°F to 400°F. Series 21000: −75°F to 175°F; 0°F to 250°F; 50°F to 300°F.



Proved Applications

Fenwal Sales Representatives and Engineers have saved time, trouble and money in all types of plants and laboratories by solving thousands of temperature control and detection problems. Fenwal THERMOSWITCH units are controlling processes that involve liquids, gases and solids.

Put Fenwal's vast reservoir of technical know-how to work for you. Chances are your problem has already been met and mastered by Fenwal engineers.

Write for new Snap-Action Catalog for details and complete information.

FENWAL INCORPORATED
195 Pleasant Street
Ashland, Mass.

Please send me your Snap-Action Catalog.

Our specific problem is:.....

.....

.....

Name.....*Title*.....

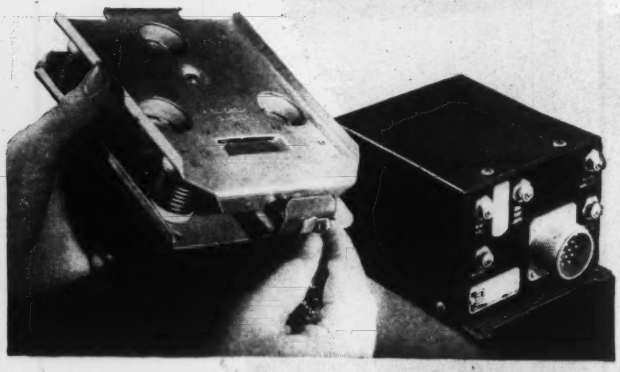
Address.....

City.....*Zone*...*State*.....

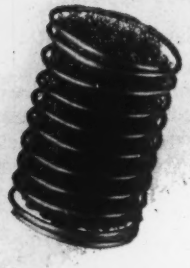
Fenwal **CONTROLS TEMPERATURE . . . *PRECISELY***

—ITEM 566—

ALLOY WIRE Cushions...



take the SHAKES out of AIRCRAFT INSTRUMENTS



Fabricated all-metal mounts have high damping properties . . . Resist deterioration.

Robinson Aviation, Inc., Teterboro, New Jersey, uses knitted stainless steel and nickel alloy wire cushions in their new all-metal engineered mounting systems to control vibration and shock in airborne electronic equipment and instruments. Alloy wire resilient cushions have attained performance standards heretofore impossible with conventional rubber or synthetic materials.

When fabricated into a special pattern, the wire forms literally thousands of tiny interlocking springs. Their high damping characteristics and non-linear spring rate provide ample protection against dynamic overloads. Alloy wire resists deterioration by oil, water, ozone, bacteria, dust and extreme temperatures. Knitted alloy wire is used in hundreds of other industrial applications, such as filters, mist eliminators, electronic shielding. For further information send today for our Application Bulletin A-1.

ALLOY METAL WIRE DIVISION

HKP H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

—ITEM 567—
For More Information Circle Item Number on Yellow Card—page 19

News Roundup

Castings Redesign Contest. Purpose of the contest is to encourage more extensive use of gray iron products. Entries will be judged on the basis of ingenuity of design, cost savings, performance advantage, and general applicability. Three cash prizes will be awarded at the society's annual meeting in November. Entries are to be mailed before July 1 to society headquarters in the National City Bldg., East Sixth St., Cleveland 14, O.

Engineers' Union Declines AFL-CIO Affiliation

WASHINGTON, D. C.—A proposal that the Engineers and Scientists of America seek affiliation with the AFL-CIO as an autonomous, nationwide union of engineering and scientific employees was defeated by a vote of 46 to 4 at the recent ESA convention. At a pre-convention meeting, the Executive Committee declined an invitation to merge with the American Federation of Technical Engineers-AFL-CIO.

HELD BY THE NOSE in this tether test rig, an XFY-1 Pogo vertical takeoff plane will be used for pilot training at Brown Naval Auxiliary Air Station, San Diego. A cable attached to the nose of the plane limits its vertical and horizontal movement. However, enough room for the maneuvering necessary in learning to fly the plane is provided between the side towers, which are 150 ft apart. The connecting bridge is 150 ft wide. A control room for test personnel is located about 40 ft from the ground.

Powerful X-Ray Machines Will Inspect Weldments

BIRMINGHAM, ALA. — A highly powerful and versatile X-ray installation is planned for use in inspection of storage and pressure vessels and for investigations of nuclear reactor chambers. Two complementary supervoltage X-ray generators rated at 1 million and 2 million volts will be built for Chicago Bridge and Iron Co. by High Voltage Engineering Corp.

An unusual mounting arrangement is planned for the one million-volt generator so that it can fit inside vessels under test. It will be fixed on the end of a 43-ft long counterweighted boom mounted on rails.

The new test installation is expected to make possible fabrication of welded vessels having greater wall thicknesses than presently.

Meetings

AND EXPOSITIONS

June 11-13—

American Society of Mechanical Engineers. Applied Mechanics Western Division Conference, to be held at the California Institute of Technology, Pasadena. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

June 11-15—

Society of the Plastics Industry Inc. National Plastics Exposition to be held at the Coliseum, New York. Additional information may be obtained from society headquarters, 67 W. 44th St., New York 36, N. Y.

June 14-16—

American Society of Mechanical Engineers. Applied Mechanics Division Conference to be held at the University of Illinois, Urbana, Ill. Additional information can be obtained from society headquarters,

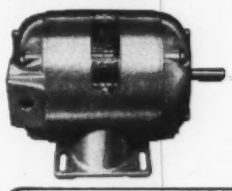
SAVE

on original development costs by using REULAND ELECTRIC'S

SPECIAL-MOTOR "LIBRARY"

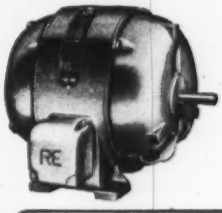
Over 900 Different Electric Motors

MOTOR #810



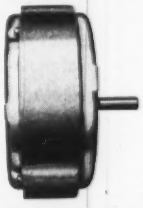
CAN BE STALLED OR "LOCKED" WITH CURRENT ON without damage. This torque motor automatically adjusts to intermittent load changes, yet maintains constant power. Available in locked service duties of 5%, 10%, 25%, 50% and 100% with maximum stalls of 5, 10, 20 or 60 minutes, *or continuous* stall.

MOTOR #569



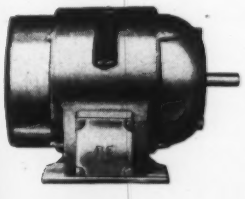
MULTI-SPEED MOTOR operates at different speeds as desired. Available in 2, 3 or 4-speed ratings in the following types:
Constant Torque—Constant torque regardless of motor's speed.
Variable Torque — For loads that maintain their own momentum.
Constant H.P.—Constant H.P. even at reduced motor speed.

MOTOR #617



WAFER-THIN, AIR COOLED, TOTALLY ENCLOSED. Originally designed for ventilation and air moving installations where it could be direct-connected to the fan *within* the piping or vent. Direct-fan attachment eliminates pulleys, belts, brackets and fan shaft. Can also be supplied in open type for mounting out of airstream.

MOTOR #402



HIGH STARTING TORQUE ON LOW STARTING CURRENT, plus variable speed are offered by the Slip Ring motor. Often permits using regular current for getting heavy loads up to full speed. Cranes, heavy fans, printing presses and crushers are typical uses. Available separately or with single or double reduction gear reducers.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY . . .

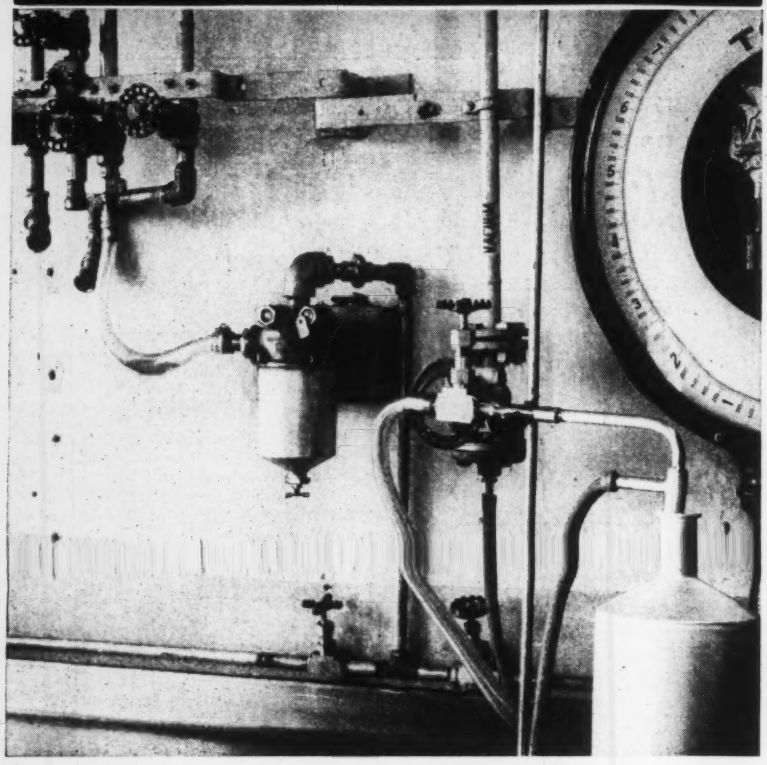
Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

RE REULAND ELECTRIC COMPANY
Distributors In All Principal Cities
Western Division: Alhambra 30, Calif. — Eastern Division: Howell 30, Mich.

—ITEM 568—

FILTER FORUM



Question:

"How do you filter a Vitamin Solution?"

A manufacturer of vitamins experienced considerable difficulty with filtration in one of his vitamin processes. The filter element used clogged after a mere 5 gallons of material had gone through. How could he eliminate frequent cleaning and maintenance and still achieve a clear, sparkling syrup?

Answer:

Ingenuity

Purolator recommended their PR-255-15 Aviation Fuel Filter. This unit is made of aluminum and contains a pleated paper Micronic® element. The filter has been extremely satisfactory. One cartridge filters 100 gallons before servicing . . . nearly 20 times more than the previous filter, with an even finer degree of filtration. Since the cartridge is of the disposable type, it is removed and replaced after each run, cutting time, handling and loss to a minimum. The excellent results of this application of a standard aviation type filter to a highly specialized operation demonstrates the advantages of Purolator's exceptional experience in solving filtration problems.

MAIL COUPON FOR DESIGN INFORMATION

PUROLATOR

FIRST in the field of filtering

Dept. D12-58, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

—ITEM 569—

For More Information Circle Item Number on Yellow Card—page 19

News Roundup

29 W. 39th St., New York 18, N. Y.

June 17-20—

American Society of Agricultural Engineers. Annual Meeting to be held at Hotel Roanoke, Roanoke, Va. Society headquarters are in St. Joseph, Mich.

June 17-21—

American Electroplaters Society. Annual Meeting to be held at Hotel Statler, Washington, D. C. Additional information can be obtained from society headquarters, 445 Broad St., Newark, N. J.

June 17-21—

American Society of Mechanical Engineers. Semiannual Meeting to be held at Hotel Statler, Cleveland. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

June 17-22—

American Society for Testing Materials. Annual Meeting and Apparatus Exhibit to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert J. Painter, 1916 Race St., Philadelphia 3, Pa., is executive secretary.

June 18-21—

Institute of the Aeronautical Sciences. Summer Meeting to be held at the IAS Bldg., Los Angeles. Additional information can be obtained from society headquarters, 2 E. 64th St., New York 21, N. Y.

June 24-26—

Alloy Casting Institute. Annual meeting to be held at the Homestead, Hot Springs, Va. Additional information can be obtained from institute headquarters, 32 Third Ave., Mineola, N. Y.

June 24-27—

Drop Forging Association. Annual meeting to be held at the Homestead, Hot Springs, Va. Additional information can be obtained from association headquarters, 419 S. Walnut St., Lansing 33, Mich.

June 25-29—

American Institute of Electrical

Engineers. Combined Summer and Pacific general meeting to be held at the Fairmont Hotel, San Francisco. Additional information can be obtained from institute headquarters, 33 W. 39th St., New York 18, N. Y.

June 25-29—

American Society for Engineering Education. Annual Meeting to be held at Iowa State College, Ames, Iowa. W. Leighton Collins, University of Illinois, Urbana, Ill., is secretary.

Aug. 6-8—

Society of Automotive Engineers Inc. National West Coast Meeting to be held at the Mark Hopkins Hotel, San Francisco. Additional information can be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

Aug. 21-24—

Western Electronic Show and Convention. Show headquarters, Pan Pacific Auditorium; Convention headquarters, the Ambassador Hotel, Los Angeles. Co-sponsored by the West Coast Electronic Manufacturers' Association and the Los Angeles and San Francisco sections representing the Seventh Region of the Institute of Radio Engineers. Additional information can be obtained from Wescon, 344 N. La Brea Ave., Los Angeles 36, Calif.

"You know, I've never seen a place expand so fast."

Your Engineer is Right!

Investment Casting permits new approaches to design and production engineering, unbound by the restrictions of traditional metallurgical practices and manufacturing techniques.

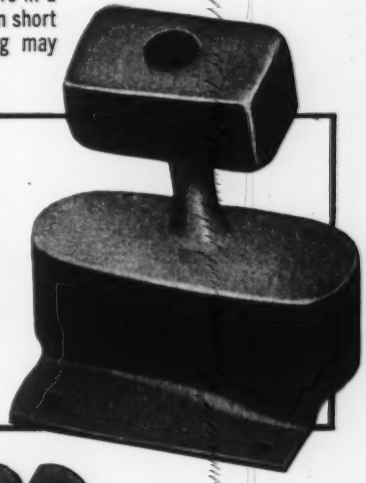
Major economies are obtained when your products or components are designed . . . or redesigned . . . with tolerance, surface and inspection criteria to conform with casting techniques. The resultant savings in final cost and production time, more than repay this small investment.

Your design engineer deserves and requires the great flexibility and latitude in design and production planning offered by Investment Casting. If application requirements demand that a part be of complex shape, intricate contours in a material that's difficult to form or machine, in short or long run quantities, Investment Casting may provide the economical answer.

CASE IN POINT!

Freedom of Design

The rudder over-balance eliminator used on the jet bomber is an investment casting of specification QQ-M-55 Magnesium, Alloy AZ-92. This intricate design is more economically produced by investment casting than any other process, permitting design freedom and assuring quality performance.



ARWOOD

ARWOOD PRECISION CASTING CORPORATION

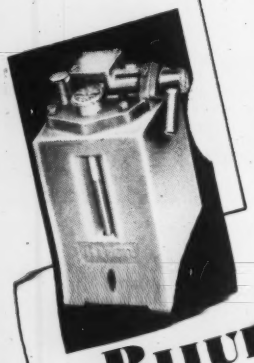
315 W. 44th St. • New York 36, N. Y.

Plants: Brooklyn, N. Y. • Groton, Conn. • Tilton, N. H. • Los Angeles, Calif.

"PIONEERS IN INVESTMENT CASTING"

—ITEM 570—

YOUR SILENT PARTNER



BIJUR
AUTOMATIC LUBRICATION
HELPS YOU
• effect real savings in your own plant
• design savings into the equipment you make

Hand oiling is costly! It wastes time and money . . . steals valuable production hours . . . means extra down-time, fire risk, repair bills, replacement parts and causes product damage from excess lubricant.

But there's a way to end all this waste and worry. A Bijur Automatic Lubrication System never forgets a bearing . . . bearings never are thirsty for oil, never flooded. Lubrication is continuous, exactly right. All the hazards of hand oiling are banished—*automatically!*

Bijur Systems are custom-engineered for machinery used by practically all industries. Every bearing receives a clean supply of oil at the right time . . . automatically and correctly metered to suit its individual needs . . . while the machine is running! Whether for new equipment you *buy*, or machines you *build*, insist on Bijur. It's better—*by design!* 1838

P-5

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

—ITEM 571—

Men of Machines

Formerly chief product engineer, **J. F. Weiffenbach** has been elected director of engineering of Fairbanks, Morse & Co., Chicago. Mr. Weiffenbach joined the company as

J. F. Weiffenbach

chief engineer of the Diesel Locomotive Div. He served successively as manager of engineering at the Beloit Works, vice president in charge of manufacturing of the Canadian Locomotive Co., then works manager of the Canadian plant. In January, 1953 he was appointed chief product engineer.

Promotion of **Wilfred W. McCullough** to development engineer has been announced by Servel Inc., Evansville, Ind. Associated with Servel since September, 1942, when he started as a wing training instructor in the wartime P-47 program, Mr. McCullough served most recently as supervisor of the quality control test laboratory.

Westinghouse Electric Corp., Pittsburgh, has appointed vice president **Frank L. Snyder** to the staff of the vice president in charge of apparatus products divisions. He will aid in directing the company's apparatus products organization. Succeeding Mr. Snyder as manager of the transformer division in Sharon, Pa., is **John H. Chiles,** who has served as engineering manager of the division since 1949. **M. E. Fagan Jr.** has been named engineering manager.

Lewis H. Whitney recently was elected president of Whitney Chain Co., Hartford, Conn. Mr. Whitney joined the company as designer and chief draftsman, was later appointed chief engineer and works manager, and was elected vice president in January, 1955.

Erwin O. A. Naumann has been named chief of advanced studies in the engineering division of Solar Aircraft Co., San Diego, Calif. Dr. Naumann has been an Air Force consultant at Wright Air Development Center for ten years. At Solar he will be concerned with advanced applications of gas turbine engines and other engineering studies.

Baldwin - Lima - Hamilton Corp., Philadelphia, has announced the appointment of **Robert R. Lent** as West Coast co-ordinator for the Electronics and Instrumentation Div. in its guided missile program. Mr. Lent's headquarters will be in the company's office in Los Angeles.

Howard C. McMillen, manager of Philco Corporation's Bedford, Ind. plant, has been elected president of the American Society of Tool Engineers.

Aero Research Instrument Co., Chicago, has appointed **Truman M. Stickney** research engineer. Mr. Stickney was an instrument engineer at Lewis Flight Propulsion Laboratories.

Earle R. Toense has joined the Digital Circuitry Section of the Data Processing Systems Div. of

SPECTOR...Chicago's largest... standardizes on Fuller ROADRANGERS®

Spector Freight Systems, Inc., largest common carrier with home offices in Chicago, is adding 104 new tractors equipped with R-46 ROADRANGERS to bring a total of 257 ROADRANGER equipped tractors to its fleet.

Referring to Spector's 149 tractors now equipped with Fuller 8-speed ROADRANGERS, to 4 tractors equipped with 10-speed ROADRANGERS . . . and to the 104 new units with 8-speed Model R-46 ROADRANGERS, C. L. Lunt, Vice President, Operations, says:

"We have standardized on the ROADRANGER Transmission for better over-all fleet performance and less maintenance . . . resulting, of course, in a substantial dollar savings. Also, our drivers overwhelmingly prefer the semi-automatic Fuller ROADRANGER Transmission."

C. L. Lunt, Vice President, Operations

Spector, whose gross revenues rose from $1½-million in 1945 to an estimated $21-million in 1955, *knows* the value of better over-all fleet performance. Spector drivers prefer ROADRANGER 8 and 10-speed Semi-Automatic Transmissions with:

- **Easier, quicker shifts—all forward speeds in short closely spaced steps between ratios**
- **One shift lever that controls all forward speeds**
- **No gear splitting—all selective gear ratios are evenly and progressively spaced**
- **Higher average road speeds—engines operate in peak hp range with greater fuel economy**
- **Less driver fatigue—⅓ less shifting**
- **Range shifts pre-selected—automatic and synchronized**

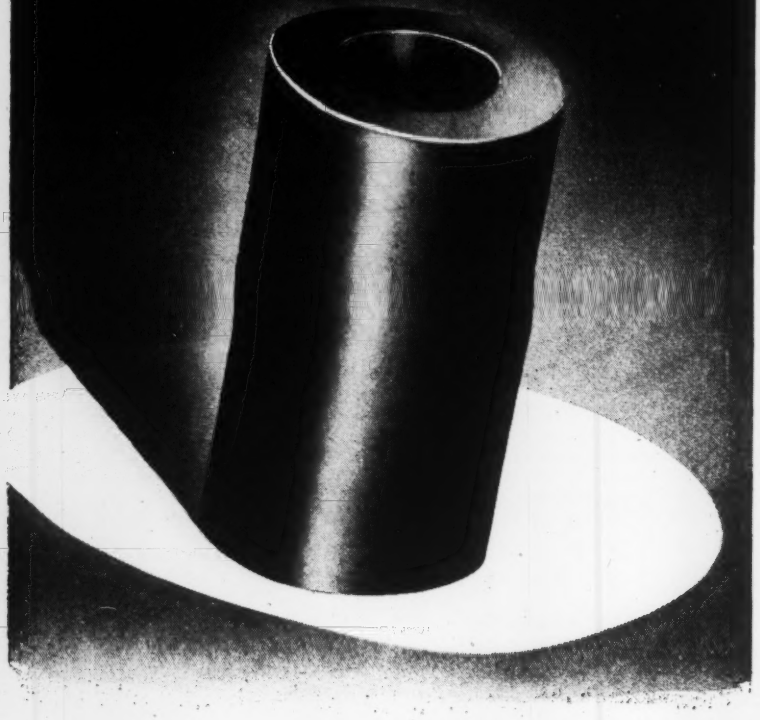
. . .

Compact space-and-weight-saving economies permit more cargo to be carried on payload axles. Get full facts on ROADRANGER from your truck manufacturer or truck dealer, now!

FULLER MANUFACTURING COMPANY
TRANSMISSION DIVISION • KALAMAZOO, MICH.

Unit Drop Forge Div., Milwaukee 1, Wis. • Shuler Axle Co., Louisville, Ky. (Subsidiary) • Sales & Service, All Products, West. Dist. Branch, Oakland 6, Cal. and Southwest Dist. Office, Tulsa 3, Okla.

How to get freedom from BEARING PROBLEMS



Here are 6 operating advantages to reduce downtime, lower maintenance and increase production

1. NO LUBRICATION
2. NO MAINTENANCE
3. NO COLD-START
4. EXTENDS SHAFT LIFE
5. RESISTS HIGH TEMPERATURES
6. RESISTS ATTACK OF Corrosive Gases and Liquids

Morganite bearings are ideal for installation in inaccessible machines, and for use in hermetically-sealed mechanisms, as well as heavy industrial equipment where high temperatures and corrosion are problems. The self-lubricating qualities are inherent, producing a highly efficient bearing under almost all conditions.

Write today for latest catalog describing the many carbon and carbon-graphite products manufactured by Morganite.

50th ANNIVERSARY 1906 · 1956

Morganite INCORPORATED

Manufacturers of fine carbon-graphite products for fifty years.
3314 48th Avenue, Long Island City 1, New York

Men of Machines

the National Bureau of Standards. He will assist in the development of high-speed memory units for computers.

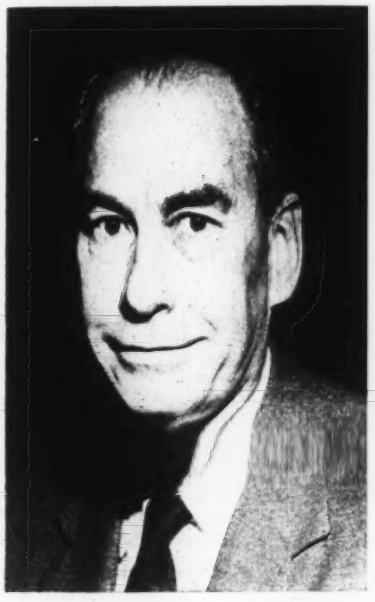
Peter Muller-Munk Associates, Pittsburgh, recently announced that **Ernst Budke III** and **Robert J. Renaud** have become associates in the firm.

The Lamme Gold Medal, awarded annually by the American Institute of Electrical Engineers, will be presented to **Clinton R. Hanna,** associate director of research of Westinghouse Electric Corp. Dr. Hanna was chosen as recipient of the award for 1955 because of "his fundamental calculations and developments in the field of electrodynamics and particularly for his achievements in the design of generator voltage regulators, automatic rolling mill controls, and tank gun stabilizers."

The Premier Co., St. Paul, has promoted **Charles M. Cassidy** to the position of chief engineer and **Warren J. Nelson,** former staff engineer, to production manager.

Thompson Products Inc., Cleveland, has appointed **John D. Stanitz** chief engineer of the Accessories Div. He succeeds **Leslie L. Aspelin,** who has been named to the new post of engineering manager

John D. Stanitz



Leslie L. Aspelin

responsible for development engineering, technical problems, and long-range planning in new fields. Dr. Stanitz will be assisted in his new post by **Robert J. Anderson** as chief technical specialist; **Frederic E. Smith** as assistant chief engineer, aircraft pumps; and **James C. Wise** as assistant chief engineer, systems.

Hicks B. Waldron has been named manager of manufacturing engineering for the distribution assemblies Department of General Electric Co. in Plainville, Conn. He joined the company in 1946 and is a graduate of the test engineering program.

Formerly manager of engineering operations, **Frank J. Skwarek** has been elected a vice president of Polarad Electronics Corp., Long Island City, N. Y.

Vern C. Vanderbilt Jr. has joined Perfect Circle Corp., Hagerstown, Ind., as chief research engineer. He was formerly a member of the faculty of Purdue University.

Van Norman Industries Inc. has announced the appointment of **Paul C. Eberhardt** as assistant to the president for manufacturing and research. Mr. Eberhardt was formerly chief machine tool engineer of the Wright Aeronautical Div. of Curtiss-Wright Corp.

ACADIA

Has 'em All Four Ways

Every customer has a right to his synthetic rubber parts the way he wants them.

The more complicated the requirements, the easier for our engineers at Acadia to go to work. Our long experience guides us in giving you exactly the characteristics you desire. We process synthetic components, for oil-resistance, good aging properties, strength, compression-deflection, or any combination you specify.

And if you require resistance to heat or cold, remember Acadia SILICONE rubber stays resilient at 100° below zero or 500° above. Silicone is molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings.

There is an Acadia Sales Engineer serving your area. A letter will put him in touch with you.

ACADIA *Synthetic* **PRODUCTS**

DIVISION OF WESTERN FELT WORKS
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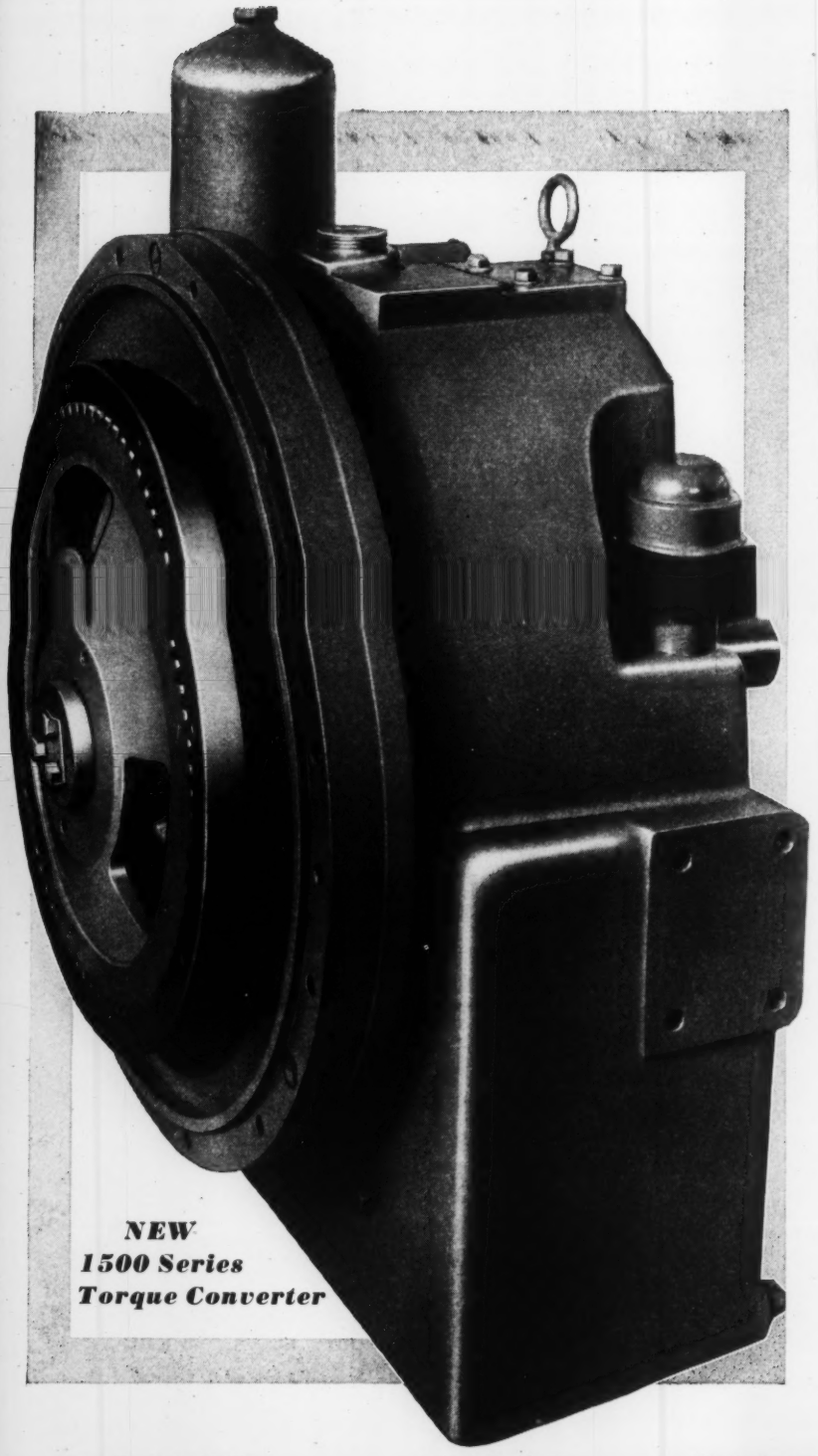
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

—ITEM 574—



Twin Disc

the world's largest manufacturer of industrial torque converters

Now! . . . Twin Disc offers a new line of *single-stage* torque converters, making Twin Disc the only manufacturer supplying both three-stage and single-stage units.

The new line of single-stage torque converters is the result of years of intensive engineering and field testing. It is of Twin Disc design and construction throughout and is not licensed from any other manufacturer, foreign or domestic.

Horsepower Range—Currently available in the 1500 Series, the new torque converter is applicable to engines producing from 30 hp at 1150 rpm to 198 hp at 2400 rpm. (See Fig. 5 for complete input hp and speed capacity range.)

Torque Capacity—Impeller bladings are available for specific torque

Fig. 1. Model "C"

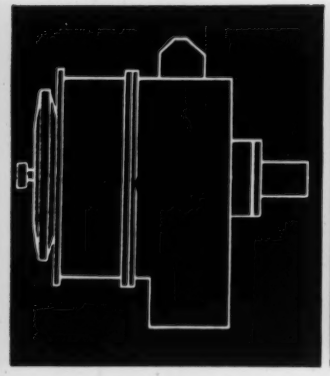


Fig. 2. Model "S"

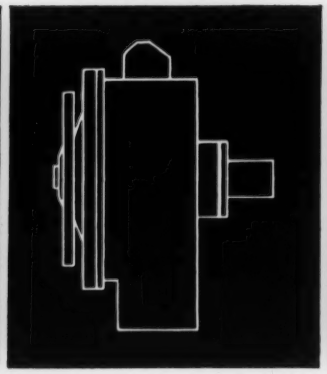


Fig. 3. Spacer-Type Model "S"

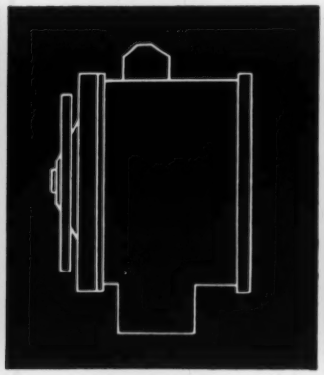
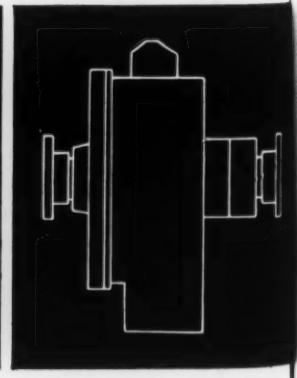


Fig. 4. Model "U"



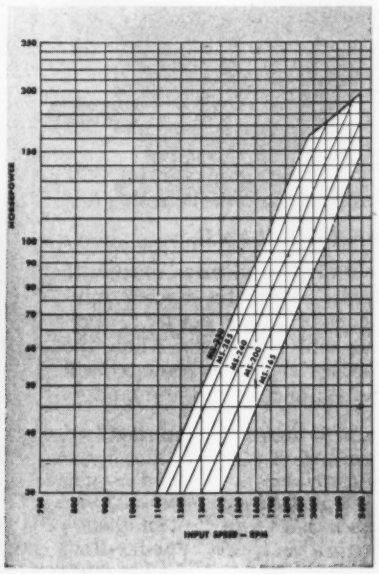
Announces new line of Single Stage Torque Converters

ratings of 165, 200, 240, 285 and 330 pound-feet.

Unloading Feature — The new Twin Disc single-stage unit features "unloading" of the engine through an exclusive blade design wherein the turbine develops a counter-head at high speed ratios, thus stopping fluid circulation. Unloading feature eliminates conventional free-wheeled stators . . . simplifies design and construction . . . makes for more trouble-free operation in the field.

One Housing, One Set of Components — Impellers having different bladings (both number of blades and pitch) are interchangeable. Thus torque capacities can be matched as accurately as possible to engines of various hp outputs and speeds without requiring changes in the converter housing or other components. Interchangeability means savings in production costs . . . savings to the customer.

Fig. 5. Horsepower and rpm capacity of the 1500 Series Single-Stage Torque Converter



Models — The new 1500 Series includes four models: (1) Model "C," with clutch input; (2) Model "S," with spider drive input; (3) the Spacer-Type Model "S," with double-ended SAE housing; and (4) Model "U," with flange input and flange output. (See Figs. 1, 2, 3 and 4 for model illustrations.)

Clutches — Model "C" arrangement is offered with either Twin Disc SP-111 or SP-114 Clutch . . . an economy feature permitting use of a smaller, more closely matched clutch for engines in the lower hp range. The spider on the Model "S" unit uses the same drive ring as the SP-111 Clutch. Therefore the same flywheel can be used.

SAE Housings—SAE No. 2 and No. 1 flywheel housings are available for both Model "C" and Model "S" units. Where the Model "C" is equipped with the SP-114 Clutch, only the SAE No. 1 housing can be used. On the double-ended Spacer-Type Model "S," No. 2 to No. 2 and No. 1 to No. 2 housings can be furnished.

Applications—Ideal for shovels, front-end loaders, bucket loaders, industrial lift trucks and other applications where single-stage torque converters offer certain advantages.

Introduction of the new 1500 Series Single-Stage Torque Converter is one more milestone in Twin Disc's long-established reputation as the world's largest manufacturer specializing in both fluid *and* friction drives for industrial applications.

Three-stage, and *now* single-stage torque converters, fluid couplings and friction power take-offs . . . Twin Disc makes them all. Whatever your drive problem, consult Twin Disc . . . for Twin Disc can recommend and furnish—*without bias*—the best drive for your application.

For further information, write today to Twin Disc Clutch Company, Hydraulic Division, Rockford, Ill.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois
Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

—ITEM 575—

THE

A B C

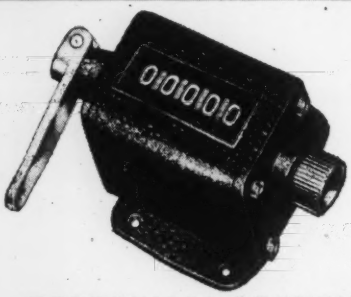
OF

1 2 3

Why is COUNTROL

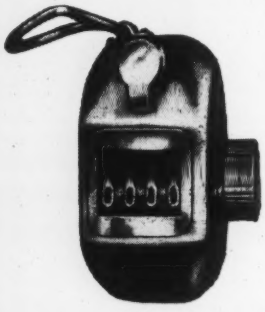
important in every business today?

Countless times a day, every business needs to know "how many? . . . how much? . . . how far? . . ." and many other questions that can be answered only by facts-in-figures. But how to get these figures . . . from so many different machines, processes, operations and systems? Veeder-Root Counters are doing it every day, by means of:



MECHANICAL COUNTING

Small Resets count strokes, turns, or pieces . . . are used by thousands for moderate duty in parts inspection, quality control, conveyors, machine tools, light presses, etc.

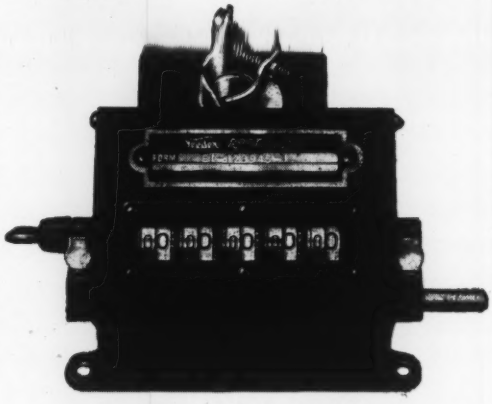


HAND COUNTING

Where objects or units cannot be counted electrically or mechanically, hand-operated counters like this Hand Tally do the job. For instance, quick spot checks of production or performance, traffic count, inventory, etc. Fits palm of hand, counts one for each pressure of thumb lever, resets to zero by turning knob.

ELECTRICAL COUNTING

These remote-indicating counters bring your production machines as close as your office wall. AC or DC, they can be connected in series with any simple switch, and will transmit production figures *instantly* over any distance. May be panel-mounted in groups.



CONTROLLING

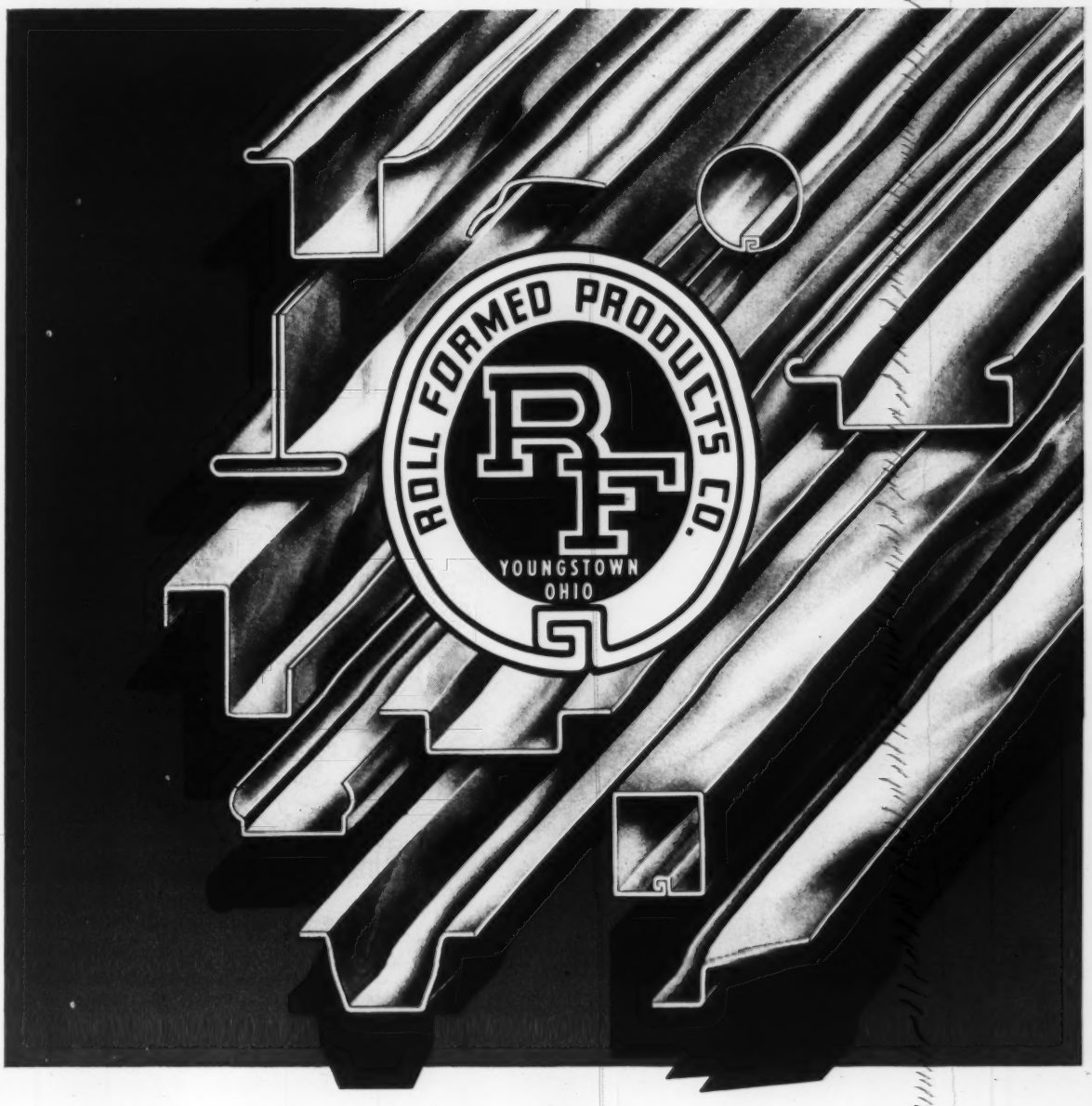
Set it for the exact number of turns, pieces, or operations required . . . and this Predetermining Counter will control the run *exactly* . . . preventing over-runs and shortages. When the predetermined number is reached, counter will light a light, ring a bell, or actuate a stop-motion.

IN SUM: *If it can be counted or controlled . . . count on Veeder-Root to do it. Get in touch with your Industrial Supply Distributor for standard counters for application to your production machines and processes. And get in touch with Veeder-Root for counters to be built into original equipment.* **Veeder-Root Inc., Hartford 2, Connecticut.**

Insist on Standard

VEEDER-ROOT COUNTERS

from your Industrial Supply Distributor



REDUCED COSTS

BY REDESIGN OR ADAPTING TO ROLL FORMED METHOD

Roll forming method is truly the automation of the stamping industry—many individual press operations are combined in a continuous production procedure. In many instances redesign is not necessary to permit production by the roll formed process, but where redesign is required our staff of qualified expert engineers are available at all times to assist you in the engineering work needed.

The old trite saying "It pays to investigate" surely applies in this case. At no cost to you, submit your inquiries, and we will do the rest.

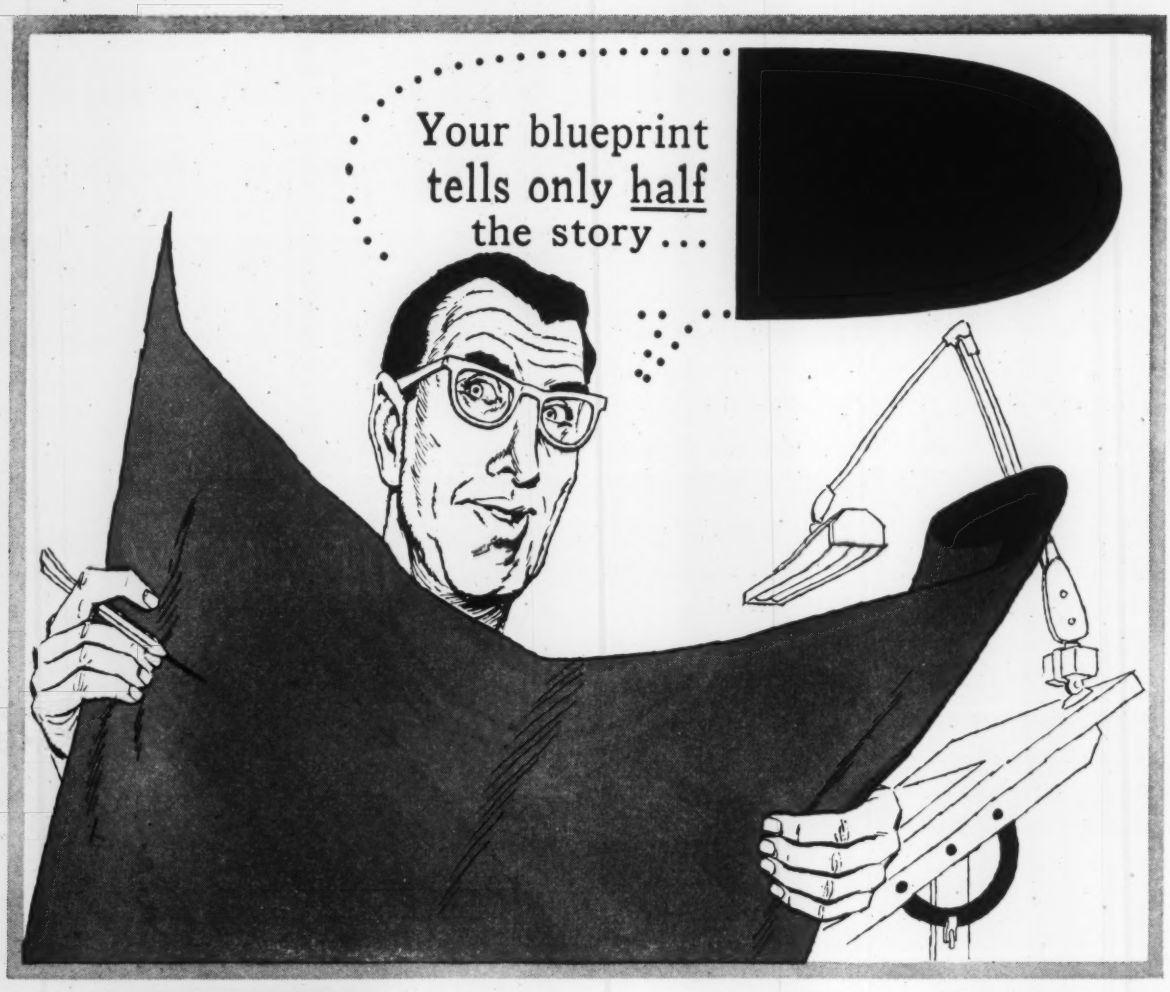
Utilizing our advanced facilities and know-how can only result in a more exact dimensioned part and a reduction in your cost.

Contact your nearest Roll Formed representative or write **Roll Formed Products Company, Youngstown, O.**

Ask for Catalog No. 1555

ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT 3754 OAKWOOD AVE. · YOUNGSTOWN, OHIO



... tell us
your performance
requirements and
Formica will save
you money!

There's never any compromise with grade selection at Formica. With 52 standard grades, and a competent research staff to develop special new ones — you won't ever have to settle for "something just as good" — or something more expensive than necessary.

Formica fabricating engineers study your blueprints, sure. But they'll also delve into where and how you'll be using your fabricated part. Then, with a thorough understanding of your requirements, they'll select the *one grade* that's best and most economical for you.

And the design modifications recommended by Formica fabricating engineers will further help to produce a better part, frequently at big savings.

This fabricating service is part of Formica-4, designed to give you the best grade at lowest cost for your application. Call your Formica district office or send us your blueprints and your performance requirements. Formica Corporation, 4545 Spring Grove Ave., Cincinnati 32, Ohio.

FI-1235

1st choice in laminated plastics

APPLICATION ENGINEERING • RESEARCH • FABRICATING • CUSTOMER STOCK SERVICE

—ITEM 578—

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

The important facts about nuts

A nut's purpose is to load the bolt in tension for a tight joint. For this, it is given shear strength greater than the breaking point of the bolt; and sufficient bearing area to avoid crushing or flow of the bearing surface with consequent reduction of tension.

While the thread form of a nut is accurate, its "lead" cannot, for practical purposes, be made identical with that of the bolt. Thus, a nut is made from material plastic enough to allow the threads to deform upon tightening and thereby adjust to distribute the load over many threads rather than concentrate it on the first few.

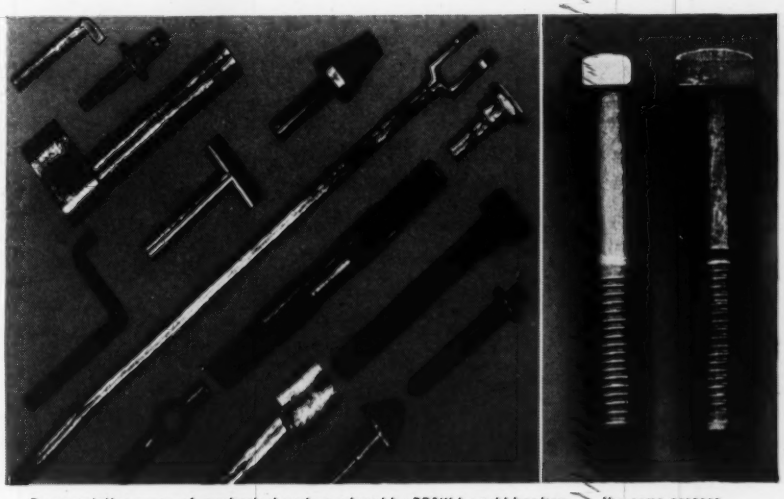
WHAT TO USE

The standard "Finished" nut series satisfies the requirements. It gives not only the required bearing area, but also enough section for proper strength and to minimize the spreading or dilation of a nut when loaded. (The standard "Heavy" nut series is called for only when bolt holes have large clearances, or for high bolt loads.)

As a good general guide to follow, use nuts that are:

1. Made to Am. Std. dimensions;
2. Made from soft, ductile material;
3. Strong enough to break the bolt or screw with which it is used. This would determine whether "Finished" or "Heavy" series is selected.

Cold heading produces strong, low cost parts



Representative range of mechanical parts produced by RB&W by cold heading . . . the same process used to produce the high quality, economical RB&W standard bolts and cap screws shown at right.

Here's a product-improving fact often overlooked: The same forming operation that produces large volumes of strong fasteners at surprisingly low cost can also be used for headed, special mechanical parts.

Cold heading upsets metal along its own axis. Flow lines are continuous, without folds, giving greater head strength against shear, fatigue and impact. Moreover, the material has better quality to start with, since unsound metal would distort or open in the operation and be rejected automatically. Uniformity is assured. Finish is also better.

Designers and production men get all these physical advantages when using RB&W standard bolts and cap screws. They can also have them in special parts at low cost when the need is of sufficient volume to justify machine set-up time. For more information and help on your specific needs, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

30% faster assembly— and joints stay tight

When famous-make chain saws were fastened with regular screws plus washers, they loosened on the job. Then SPIN-LOCK screws were used. These not only held tight, they also speeded assembly time 30%. What's more, they cost no more than former screw plus lock washer.

SPIN-LOCK screws have self-anchors in the form of hardened, tiny teeth which dig in and hold under severe service. Various types, sizes and heads available. Send for data or see Sweet's Product Design File.

—ITEM 579—

Next Page—ITEM 580→

GENERAL ELECTRIC
DIRECT CURRENT MOTOR

rrent Motor

KINAMATIC* a new standard in direct-current motors, gives your machines wider

speed ranges, greater output

To meet modern industrial needs for faster, more automatic, more continuous production, General Electric has designed an entirely new direct-current motor—the d-c Kinamatic.

Designed for Automation—Now, a direct-current motor has been designed for the modern job it has to do—either as individual motor drive or in regulating systems. The new General Electric d-c Kinamatic motor supplies the wide speed range and versatility required for today's manufacturing methods. It is designed for the close control of machines and split-second timing of processes essential to higher output.

Accelerated Production—The new d-c Kinamatic motor will modernize your equipment, give it increased power, higher speeds, greater output capacity. With the quick-acting G-E Kinamatic motor, your machines will process a greater variety of products . . . faster . . . easier . . . and with less maintenance and spoilage.

More Powerful—By combining advanced design with improved materials and manufacturing techniques, General Electric engineers have packed more power into the entire Kinamatic line. The powerful Kinamatic motor, with new stamina and durability, is ready to become one of your most effective weapons for keeping costs down, for meeting competition, for boosting productivity levels.

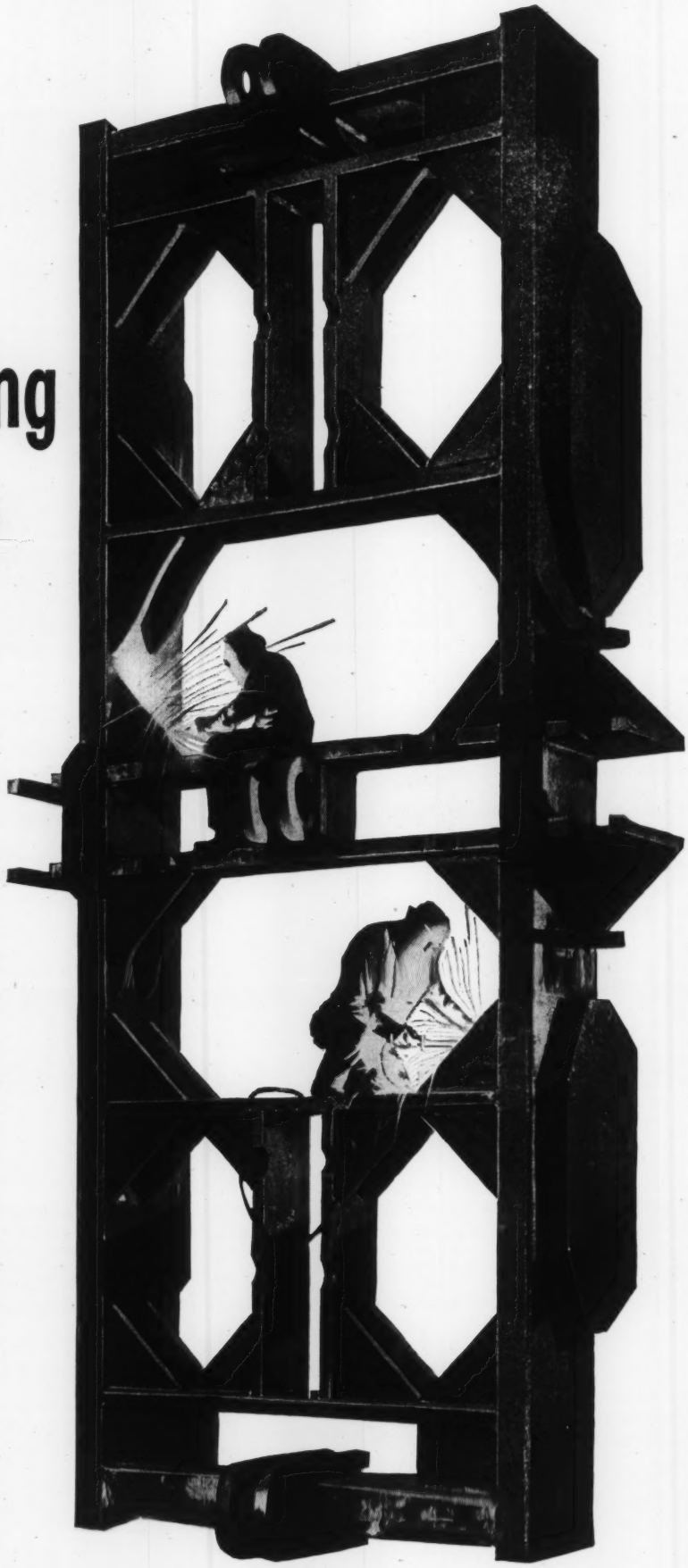
Engineering Help—Industrial specialists in 149 conveniently located General Electric Apparatus Sales Offices have the complete story on how the new d-c Kinamatic motors and generators can benefit your operation. For full details, contact your G-E Sales Representative, or write for Bulletin GEA-6355. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 813-1

* Trade Mark of the General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC

Weight-Lifting CHAMP



Steel ingots weighing 375 tons—the largest made—are safely handled by this hefty lifting beam, shown during fabrication in our Weldment Shop.

Welded construction permitted the designers to provide plenty of strength and rigidity while eliminating unnecessary weight. And that's especially important in a lifting beam, where every excess pound is dead weight.

If you have a job in mind that calls for strength and rigidity with the least possible weight, we suggest that you consider a weldment. And when you do, please remember that our Weldment Shop specializes in custom weldments of every type: machinery frames, press bases, pressure vessels, etc. May we give you more information? Just call or write the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation.
Export Distributor: Bethlehem Steel Export Corporation

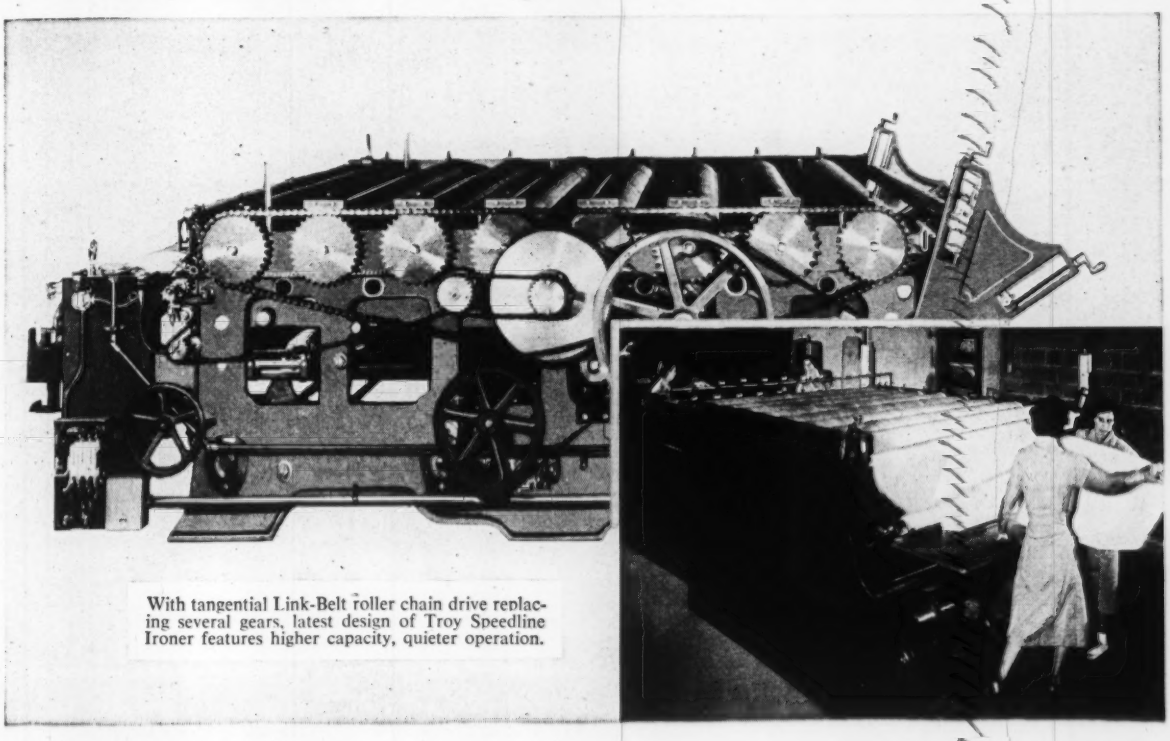
BETHLEHEM STEEL

BETHLEHEM STEEL

—ITEM 581—

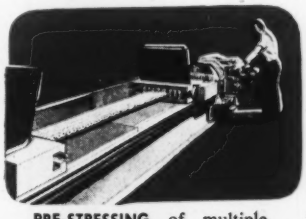
These EXTRAS make Link-Belt Roller Chain

a credit to your machine



With tangential Link-Belt roller chain drive replacing several gears, latest design of Troy Speedline Ironer features higher capacity, quieter operation.

LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.



PRE-STRESSING of multiple width chain provides uniform load distribution.

SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

INCLUDE Link-Belt Precision Steel Roller Chain in your design—and you've a better machine to show for it. Vital extras added to top-standard manufacturing methods give this chain an edge in strength and durability . . . longer service life.

For wide design flexibility, Link-Belt roller chain covers the range of single and multiple widths—¼ through 3-in. standard pitch and 1 through 3-in. double pitch with sprockets of corresponding sizes. The 148-page Data Book 2457 furnishes complete application details. Ask your Link-Belt office for a copy.

Remember Link-Belt, too, for all other drive and conveying chain. Silent, cast, combination, forged and fabricated steel chains—sizes and types for all requirements are included in this complete line.

LINK-BELT

12040

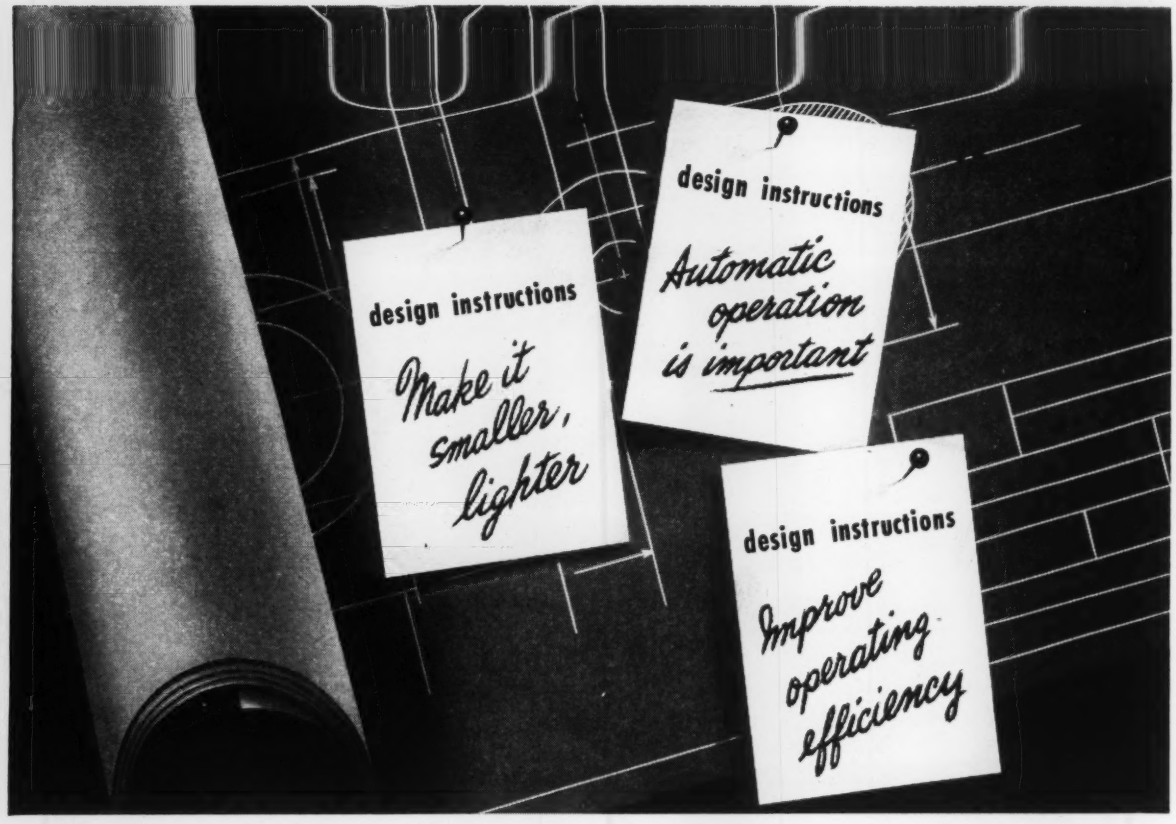
CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

Silent Chain | LXS Steel Chain | Detachable Steel Link-Belt | S-815 Flat-Top Chain | Cast and Cut-Tooth Sprockets

—ITEM 582—

For More Information Circle Item Number on Yellow Card—page 19



Are You Aware of the Exciting Opportunities for Product Improvement that Exist Now?

Today, industry is forging ahead in the development of products little dreamed of only a few short years ago.

Instrumentation . . . miniaturization . . . more automatic production . . . all are demanding parts and components with new operating advantages. And High Nickel Alloys are playing an important part in meeting the needs. Are *you* aware of the opportunities High Nickel Alloys offer? For example, do you know you can . . .

. . . Design smaller, lighter weight units through the use of "extremely sensitive" alloys that respond to very weak electrical currents?

. . . Assure precision product performance with the help of an alloy that exhibits infinitesimal size change through temperature ranges up to 400°F?

. . . Compensate a given magnetic field for temperature changes to insure consistently accurate product performance?

And the list goes on . . . an exciting list of properties that can lead to rewarding fields of new and improved products!

Getting High Nickel Alloys to do special jobs for you . . . making them behave in the way *you want them to behave* . . . is an opportunity we welcome. By making a team of your engineering experience and Carpenter's ability to produce closely controlled High Nickel Alloys with predetermined behavior, you often take an immediate step to product improvement. To help you in this job, Carpenter manufactures an unusually complete line of High Nickel Alloys . . . Temperature Compensator, Low Expansion, High Permeability and Glass Sealing Alloys. These are available in the largest variety of forms including strip, wire, bars, tubing, forging billets, etc. Ask for detailed engineering and application information. A note on your company letterhead is all that's necessary.

Carpenter STEEL — **High Nickel Alloys**

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
THE CARPENTER STEEL COMPANY, 120 W. Bern St., Reading, Penna.
Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

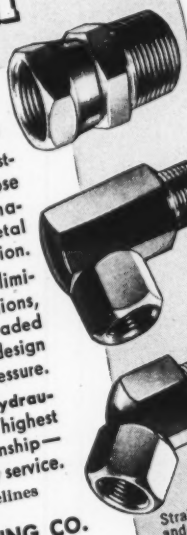
—ITEM 583—
For More Information Circle Item Number on Yellow Card—page 19

Designers and Engineers... Clip these reminders to specify

Eastman
first in the field

HYDRAULIC HOSE ASSEMBLIES

Stop torsional strain with Eastman ADAPTER UNIONS



Straight and Angled Adapter Unions

Eastman Design and Engineering Guarantees Tight Fit . . . Easy Action

● **Eastman Adapter Unions** prevent twisting and assure proper positioning of hose lines when being installed. Accurate machining assures leakproof metal-to-metal seat as effective as a ground joint union.

● **Eastman Angled Adapter Unions** eliminate the use of elbows and pipe unions, thereby reducing the number of threaded connections. Original Eastman design provides tight-fitting joint at any pressure.

● **Eastman, "First in the Field of Hydraulic Hose Assemblies,"** stands for the highest quality of material and workmanship—your best assurance of satisfactory service.

"Safeguarding Industry's Lifelines of Mobile Power"

EASTMAN MANUFACTURING CO.
Since 1914
Dept. PE54, Manitowoc, Wisconsin

Eastman
first in the field
HYDRAULIC HOSE ASSEMBLIES

Send for Eastman Form No. 231-B, 232-B for sizes, angles available.

Specify Eastman HYDRAULIC HOSE ASSEMBLIES

● Profit from Eastman's 26 years' experience in Hydraulic Hose Assemblies. Pressed-on, re-usable and renewable couplings and insert type fittings for high and low pressure air, gas, water, paint, grease and hydraulic hose...from ⅛" to 2". Pressure lines up to 5000 psi. Also suction and low pressure units.

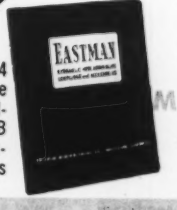
WRITE FOR COMPLETE CATALOG OR PHONE YOUR SPECIFICATIONS

EASTMAN MANUFACTURING CO.
Since 1914
Dept. PE54, Manitowoc, Wisconsin

Eastman
first in the field
HYDRAULIC HOSE ASSEMBLIES

SAFEGUARDING INDUSTRY'S Lifelines of Mobile Power

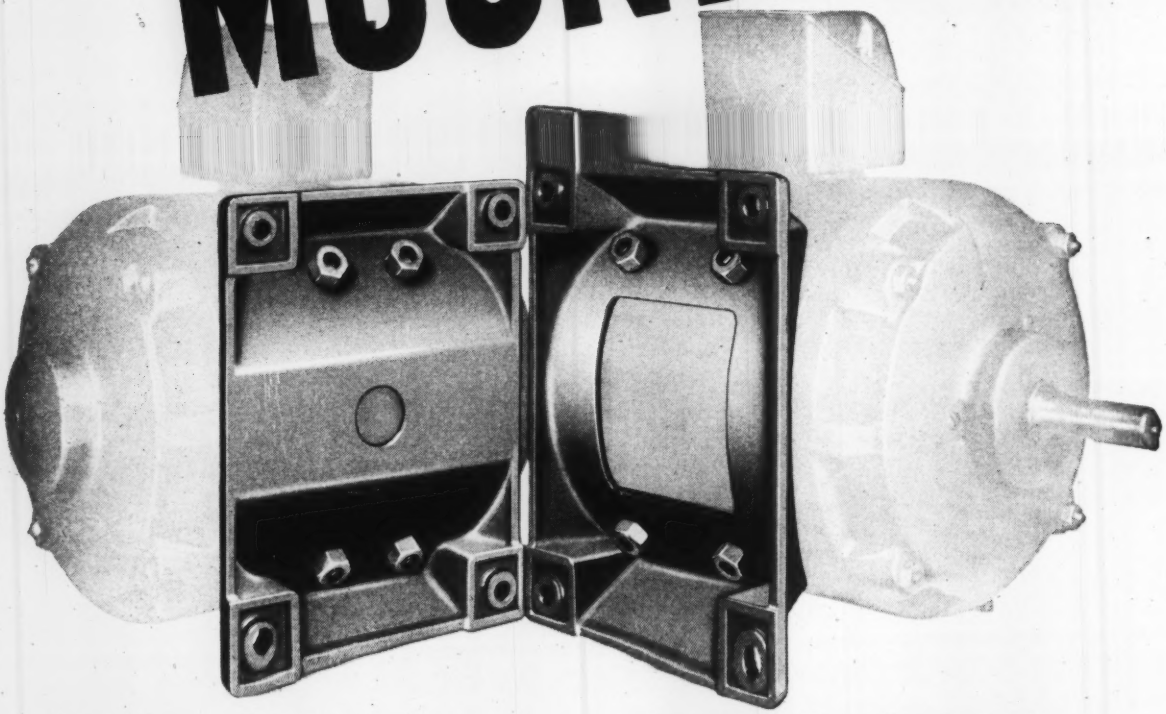
Write for free catalog 104 on Eastman Hose Couplings and Bulletins 231B & 232B on Straight and Angled Adapter Unions



Eastman
MANUFACTURING COMPANY
Since 1914
Dept. MD-5, Manitowoc, Wisconsin

Optional FRAME MOUNTINGS

A. O. Smith



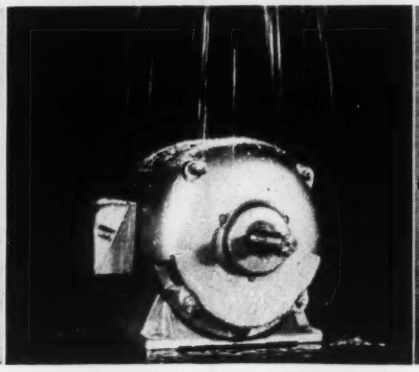
Want to use new NEMA mounting dimensions for integral horsepower motors?
Do it with A. O. Smith Integrals! Optional frame mountings fit NEMA sizes 182, 184, 213, 215.

Want to keep old mountings but still enjoy all the advantages of new NEMA ratings?
Do it with A. O. Smith integrals! Optional frame mountings fit old NEMA sizes 203, 204, 224, 225.

You get these quality A. O. Smith motor features...

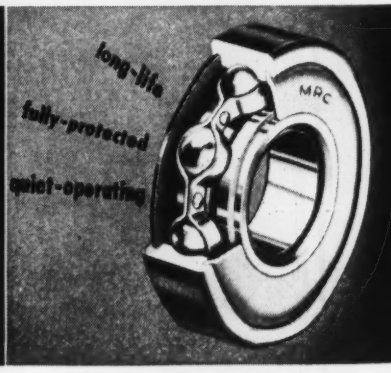
SEALED STARTING SWITCH AND ACTUATOR

Exclusive development . . . totally-enclosed in end frame. No need to remove motor from line for switch service.



DRIP-PROOF CONSTRUCTION

Motor can be mounted in any position . . . drip-proof thru 360° cycle . . . simply rotate end brackets. No foreign matter can enter vent holes.



PRE-LUBRICATED BEARINGS

Shielded bearings assure protection against over greasing . . . provide even load distribution under all working conditions . . . quiet operating.

integral hp motors have

frame mountings to *fit your product specifications*...

with either *new* or *old* NEMA dimensions.

THERE'S no need to change product design or manufacturing processes to enjoy all the advantages of new NEMA specifications for integral hp motors. A. O. Smith offers you motors with optional frame mountings — either the old specifications or the new.

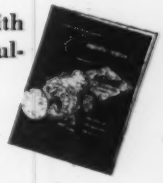
Optional frame mountings for integral hp motors is one of the features used by A. O. Smith in "Application Engineering" motors to your particular design requirements. There's no need to adapt your product to the design limitations of a conventional motor.

Whatever your speed or design requirements, there's an A. O. Smith integral hp motor available to power your products. Integrals are built in single and polyphase . . . in various speeds and frequencies . . . choice of frame mountings for either old or new NEMA dimensions . . . C and D flanges with special flanges as required . . . 1 thru 150 hp.

Produced by one of America's great industrial concerns, these motors are backed by a national network of 270 strategically-located factory service stations.

There's one near you — ready to provide 24-hour action on all parts and service orders.

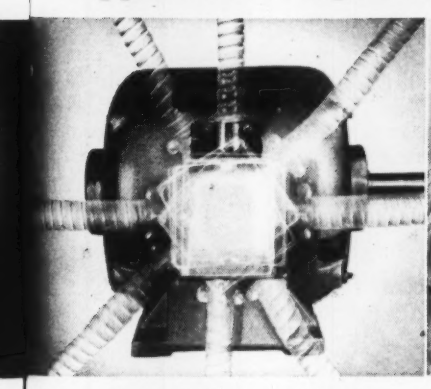
For more information on A. O. Smith integral hp motors, write for new Bulletin No. EM156.



Through research A.O. Smith *. . . a better way*

A.O.Smith
CORPORATION
TIPP CITY, OHIO
International Division: Milwaukee 1, Wisconsin

application-engineered to match your product requirements

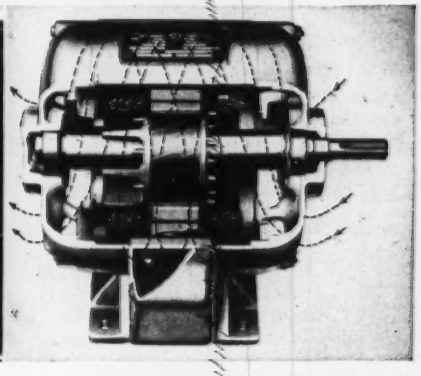


FULL-ROTATING CONDUIT BOX

Can be set at any angle. Designed to save motor space and speed installation. Loosen only three screws to rotate conduit base.

DYNAMICALLY-BALANCED ROTOR

Assures continuous, vibrationless, trouble-free performance and maintains long bearing life. Indestructible laminations are high-quality silicon steel.



CONTROLLED THRU-VENTILATION

Cooling system designed for high-volume, low velocity air for maximum heat transfer. Temperature held to absolute minimum, assuring longer insulation life.

Large OD Thin Wall Tubing offers New Answers to Design Problems

Superior specializes in an unusually wide range of analyses, shapes and sizes

Today's design engineers are finding large OD thin wall tubing by Superior answers more and more of their design problems. Its light weight makes it ideal for ducting, fuel and oil lines in aircraft. Thin wall tubing also functions efficiently as a low pressure heat exchanger tube. Because of its close tolerances, ductility, and bright, clean OD and ID surfaces, Superior thin wall tubing is an excellent choice for flexible metal hose for the food, chemical and aircraft industries. Other applications include bellows, solenoid cylinder cores, cylinder liners for automobile hydraulic brakes, fractional horsepower motor casings, ceramic drills, electron power tube anodes and cathodes, and casings for radioactive well logging instruments.

A number of analyses in large OD thin wall seamless and Weldrawn® tubing are available at Superior. Stainless, carbon and alloy steels, beryllium copper, titanium, nickel and nickel alloys are offered in sizes up to 1⅛" OD with .035" wall maximum; Monel and certain analyses of stainless steel in sizes to 2½" OD with .025" wall maximum.

Superior tubing can be supplied in random, multiple or cut lengths up to 30 feet, and in any of three standard tempers (fully annealed, soft; half-hard drawn; full-hard drawn) or in special tempers required by Government, aircraft and customer specifications. Thin wall tubing can be shipped in special cardboard cylinders, to protect it from dents and scratches.

For additional information, get your free copy of Data Memorandum No. 4. Write to Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

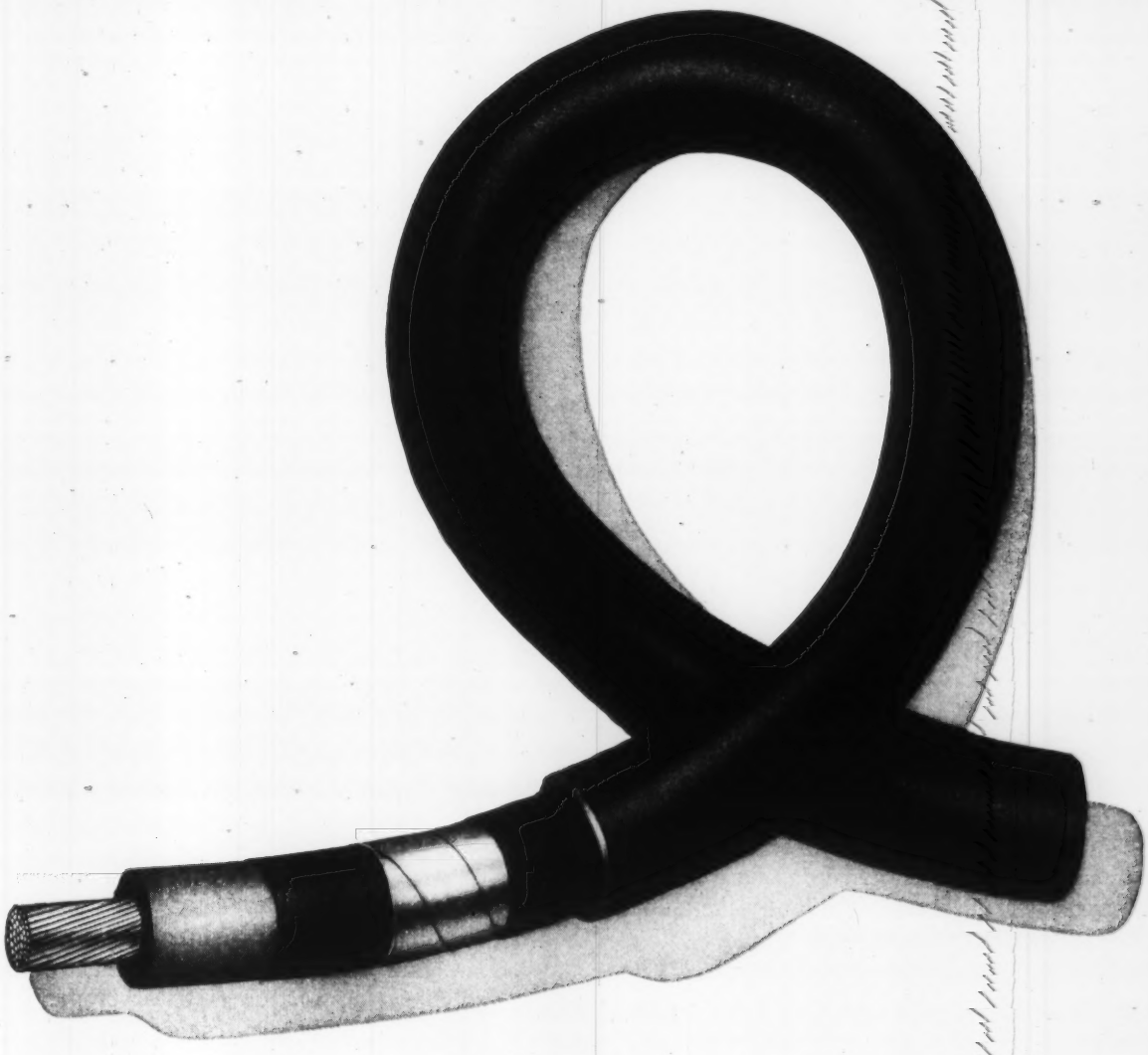
NORRISTOWN, PA.

All analyses .010" to ⅜" OD—certain analyses in light walls up to 2½" OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

—ITEM 586—

For More Information Circle Item Number on Yellow Card—page 19



Anaconda specifies Enjay Butyl rubber

TO DEFY OZONE IN HIGH-VOLTAGE CABLES...

for more current per circuit... more power per dollar

Anaconda specifies Enjay Butyl insulation for high-voltage cables because this rubber has incredible resistance to ozone. Surpassing the industry's standard three-hour specification test, Enjay Butyl insulation used by Anaconda showed *no injury after 72 hours* of ozone concentration tests—24 times longer than specification requirements. Other rubbers would deteriorate and crack in a fraction of this time.

With the help of Enjay Butyl, millions of feet of Anaconda's cable now in use deliver more current per circuit, more power per dollar.

Perhaps *your* product, too, can be improved with versatile Enjay Butyl. It comes in non-staining grades for white and light-colored parts, offers excellent electrical properties, low price and *immediate availability*. For full information, contact the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

AUTOMATIC CONTROL OF

• *A REEVES engineering report on a new control that completely automates mechanical variable speed . . . accurately controls and integrates processing variables*

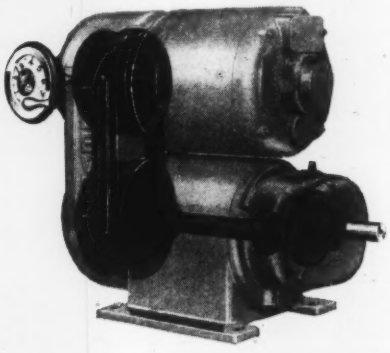
New Control Demands

Recently, with the intensified interest in automating production and processing lines, there developed many new measuring instruments whose signals had to be translated into automatic control of variable speed drives. These signals reflected changes in many variables—such as pressure, flow, weight, level, color, light intensity, radio-activity and peripheral speed.

The instrumentation industry has been ingenious in developing devices to sense and measure these variables, translating them into the industry standard of 3 to 15 psi air pressure; each equal increment of change in psi representing a linear change in the measured signal.

The need, then, has been for some type of automatic control to accurately and continuously transfer the instrument air signal to equally proportioned changes in the output speed of the variable speed drive.

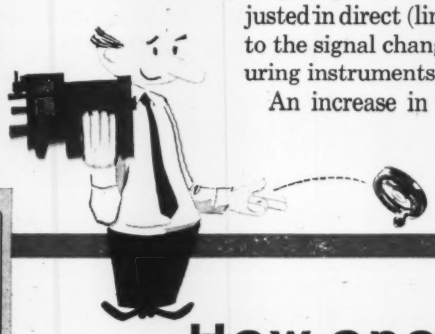
The most logical choice for the basic mechanical variable speed drive is the versatile and efficient REEVES Motodrive . . . an inexpensive power package that combines the motor, variable speed mechanism and gear head reducer into one compact unit. The Motodrive operates on the time-tested principle of a V-belt driving between two pairs of cone-shaped discs which are adjustable to form an infinite number of driving and driven pitch diameters to give variable speed at the output shaft.

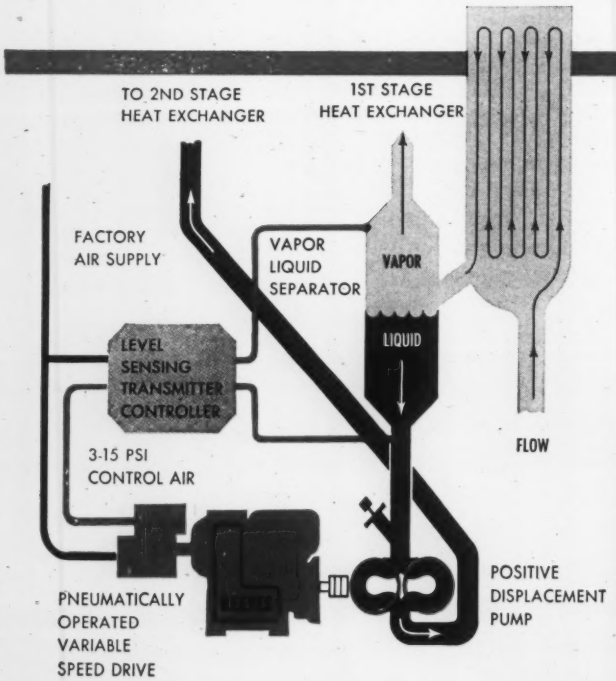


Reeves Automatic Control

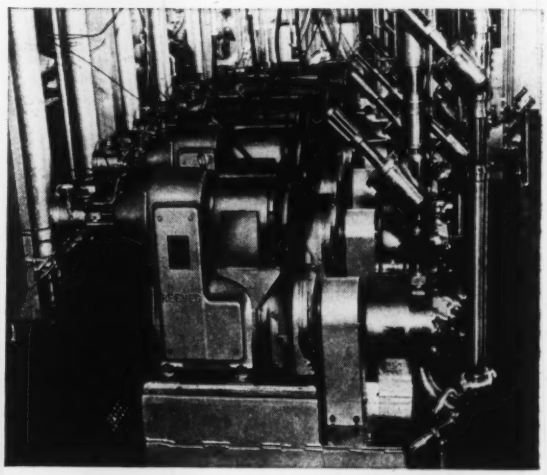
By replacing the manual "handwheel control" of the Motodrive with a pneumatic REEVES Automatic Control, output speeds are continually adjusted in direct (linear) proportion to the signal changes of the measuring instruments.

An increase in the instrument





How one plant

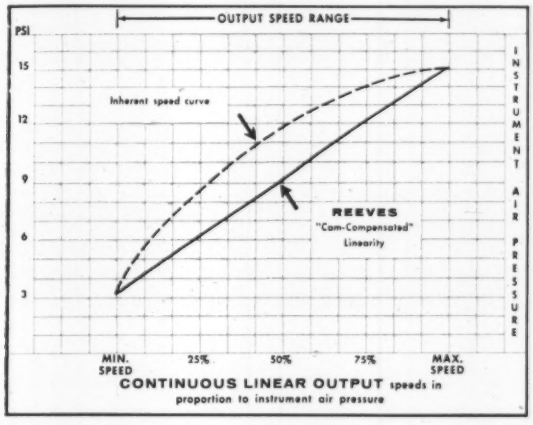


VARIABLE SPEED DRIVES

control pressure activates a valve, admitting supply air to a cylinder chamber. This force against the air piston in the cylinder moves the speed shifting mechanism of the REEVES Motodrive to increase the output speed.

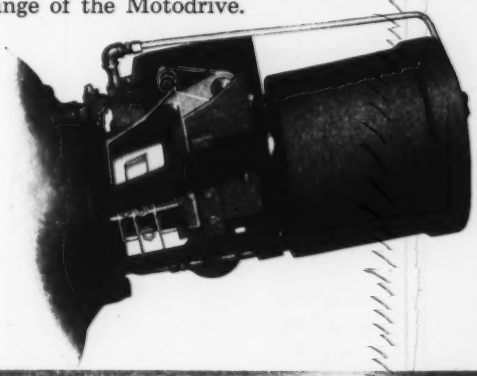
A decrease in control pressure exhausts air from the cylinder chamber, causing a decrease of the output speed. Any change, therefore, in control pressure of the measuring instrument gives an automatic corresponding change in the output speed of the REEVES Motodrive . . . resulting in exact processing control.

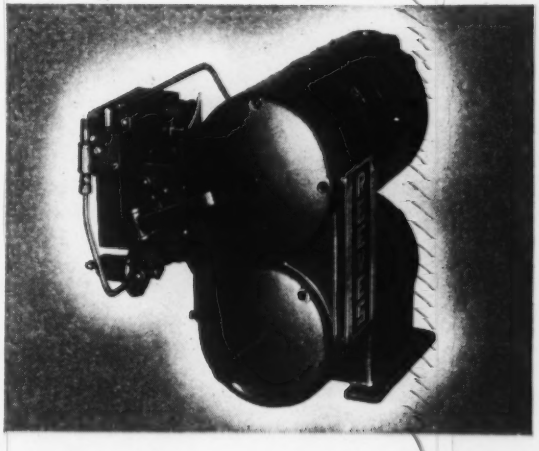
Cam-Compensated Design



The output speed of this type of variable speed drive with standard controls is in the form of a curve.

The REEVES Automatic Motodrive incorporates a cam to control output speeds in direct (straight line) proportion to instrument air signal variations. This cam is contoured to produce linear speed changes over the entire output speed range of the Motodrive.





utilizes this Reeves Control

Evaporating the natural waters from fruits to produce fruit concentrates has greatly reduced the cost of packing and shipping of fruits.

Great care must be exercised in the exposure of the fruit pulp to temperature and pressure to retain the natural flavor.

A recently designed and remarkably fast one-pass process incorporates REEVES Automatic Motodrives to automatically control the critical relation between concentrate density and rate of flow.

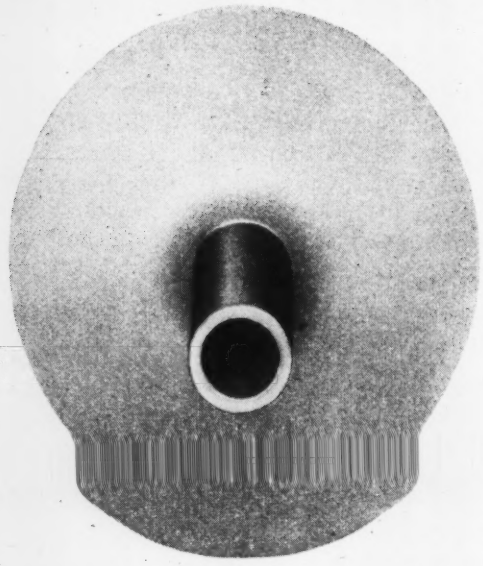
As water is evaporated from the fruit pulp, the smaller volume reflected by the dropping level in the liquid-vapor separator is sensed by a pressure differential transmitter.

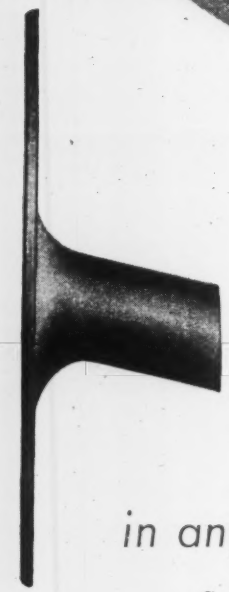
Converted to 3-15 psi air, this signal works through the automatic controller to reduce the speed of the REEVES Motodrive and, in turn, the speed of the constant displacement discharge pump.

The REEVES Automatic Motodrive, used in connection with modern instrumentation, is your answer to flexible, sensitive, accurate speed control for automatic processes.

We don't know *all* the possible applications for this control . . . but our engineers will be glad to work with you on *your* design problems.
For more details, write for Bulletin H25-M542.

REEVES DIVISION • COLUMBUS, INDIANA
RELIANCE ELECTRIC AND ENGINEERING CO.

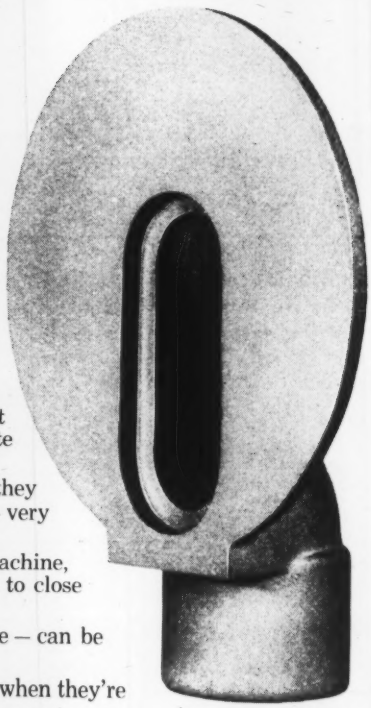




from Crucible

Aircraft Quality STAINLESS INVESTMENT CASTINGS

in any shape or grade . . .



Can your product benefit from the important features shown in these Crucible Accumet® precision investment stainless castings? They are tube supports for jet aircraft engine assemblies, but the characteristics they illustrate are just as vital to thousands of other applications.

THIN WALLS — Accurately produced by the Accumet casting process, they are impossible to make in sand or shell mold castings — very difficult to forge.

BLIND HOLES — like this one, are impossible to forge, expensive to machine, and very difficult to sand cast . . . but they can be held to close tolerances by Accumet casting.

CORING — Deep or intricate cores — prohibitively costly to machine — can be economically produced by the Accumet process.

ODD SHAPED PARTS — difficult to chuck and machine, are economical when they're Accumet castings.

Next time your designs call for parts with intricate shapes . . . close tolerances . . . fine finish . . . high quality and uniformity, make them Crucible Accumet castings. They are available in any grade of steel or high alloy your product calls for. Let a Crucible engineer give you all the facts about how Accumet castings can save you time and money. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

Write for a **free** copy of the informative folder "Accumet Castings".

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

—ITEM 589—

For More Information Circle Item Number on Yellow Card—page 19

Photo shows hairline contact of LPD Clipper Seal which provides negligible torque when seal is tested on dry run of torque measuring apparatus.

How J-M Clipper Oil Seals cut shaft drag

line contact minimizes interference... provides cooler running

Take a close look at the lip of a Johns-Manville Clipper Seal. You'll see how the bearing area has been narrowed down to a sharp line contact. That's why you get less power consumption and lower operating temperatures when you use Clipper Seals to seal in lubricant, seal out dirt.

What's more, this line contact requires less lubrication and yet receives far more in proportion to its surface than any other design. It all adds up to greater sealing efficiency and longer seal life for Clipper Seal users. This exclusive line contact feature is provided on all LPD Clipper Seal designs which are adaptable to most applications.

Lower torque is only one of many advantages you get with J-M Clipper Seals. Precision moulded from a variety of corrosion-resistant compounds specially developed for each service, they provide maximum sealing ability, long life, wide adaptability and easy installation. For more information on the complete line of Clipper Seals, write for new 28-page illustrated brochure PK-71A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada: 565 Lakeshore Road East, Port Credit, Ontario.

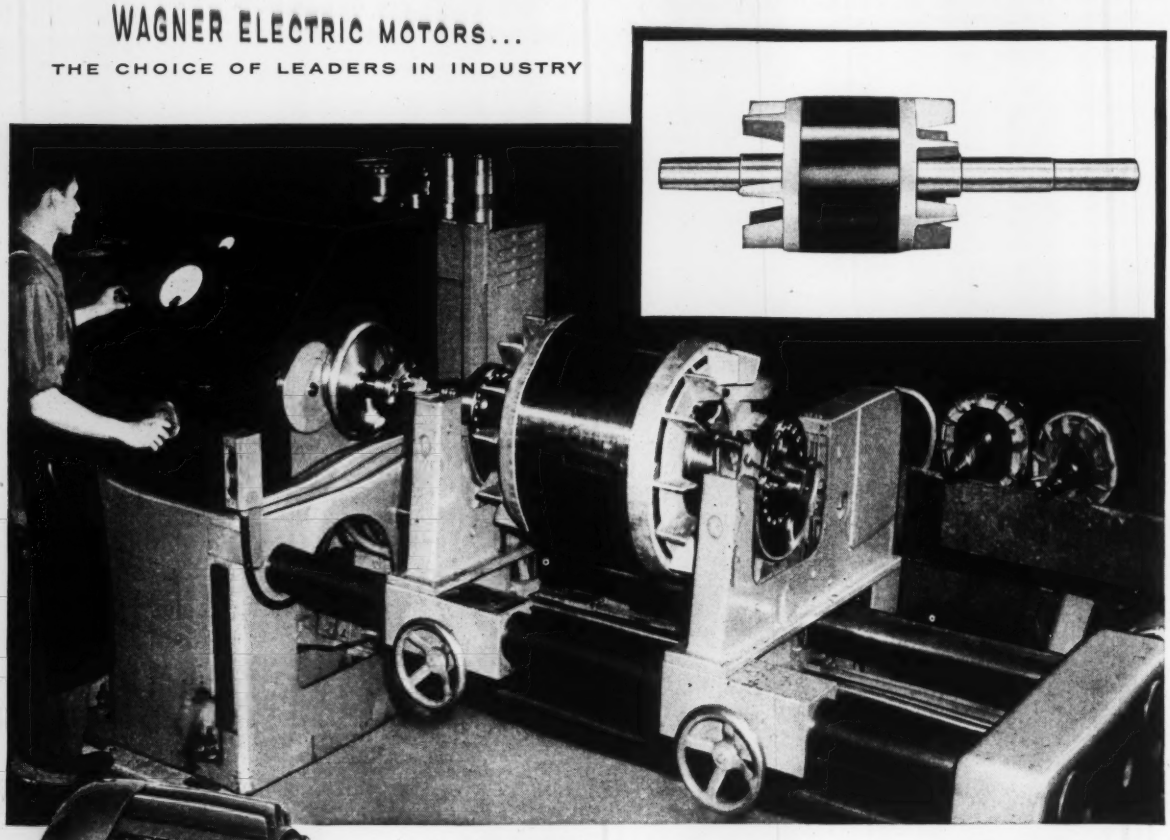
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

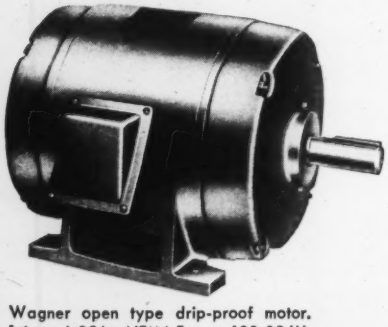
—ITEM 590—

WAGNER ELECTRIC MOTORS...

THE CHOICE OF LEADERS IN INDUSTRY



Wagner totally-enclosed fan-cooled motor.
1 through 30 hp, NEMA Frames 182-326U.



Wagner open type drip-proof motor.
1 through 30 hp, NEMA Frames 182-326U.

DESIGNER'S NOTE:

All Wagner Motors are *DYNAMICALLY BALANCED* for smooth performance

Motor balance is important to fine machine tool performance. A well-balanced motor greatly reduces vibration—allows your machine tools to turn out the accurate work for which they are designed.

Every rotor, even in the smallest fractional hp rating, used in a Wagner Motor is dynamically balanced on balancing machines like that shown above.

Your selection of Wagner Motors for your machine tool applications gives you other benefits, too. You can specify totally-enclosed motors that are fully protected against damage from filings, chips, dirt, fumes, moisture; or open type drip-proof motors—in ratings through 500 hp. You add an extra selling point—Wagner Motors are *known* for dependable performance. You assure users freedom from costly motor maintenance and even more costly down-time. And—you give your customers motors that can get on-the-spot service when needed—anywhere in the United States.

M56-9

Wagner Electric Corporation
EST. WE 1891

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

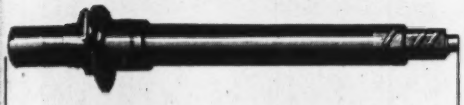
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

—ITEM 591—
For More Information Circle Item Number on Yellow Card—page 19

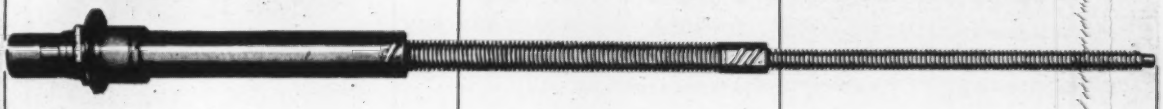
Saginaw SOLVES ANOTHER POSITIONING PROBLEM!

PROBLEM: SHORT ACTUATOR SPACE



SOLUTION: THIS NEWLY DEVELOPED

SAGINAW MULTI-EXTENDING b/b SCREW EXTENDS SEVERAL TIMES ITS RETRACTED LENGTH



RETRACTED

HALF EXTENDED

FULLY EXTENDED

Now, the pioneer in the development of the precision ball/bearing screw and spline offers you another great engineering advancement:

a practical and dependable solution for your most difficult actuator space problems!

The Saginaw Multi-Extending b/b Screw is the answer design engineers have been seeking for years because:

1 It provides extended lengths in approximate multiples of its retracted length

2 It will carry a far higher load than any other telescoping device in its class

3 It is far more practical and troublefree than previously available telescoping units

4 It assures dependable, precise positioning within thousandths of an inch

PLUS ALL THESE PROVED SAGINAW ADVANTAGES

- *90% efficiency guaranteed*
- *Requires up to 1/5 less torque than Acme screws*
- *Less drain on power supply*
- *Conserves space and weight*
- *Operates dependably at extreme temperatures*
- *Functions perfectly with only initial lubrication*

Can be built in a wide range of diameters and extended and retracted lengths

Saginaw ball/bearing Screw

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • Saginaw, Michigan

MAIL COUPON TODAY FOR NEW ENGINEERING DATA BOOK

Saginaw Steering Gear Division
Ball Bearing Screw & Spline Operation
General Motors Corporation
Dept. 5H, Saginaw, Michigan

Please send your b/b Screw and b/b Spline Engineering Data Book to:

Name—Title_____

Firm_____

Address_____

City_____ Zone____ State_____

—ITEM 592—

For More Information Circle Item Number on Yellow Card—page 19

Next Page—ITEM 593→

LINDBERG INDUCTION UNIT IMPROVES HEAT TREATING PROCESSES AT J.I. CASE...

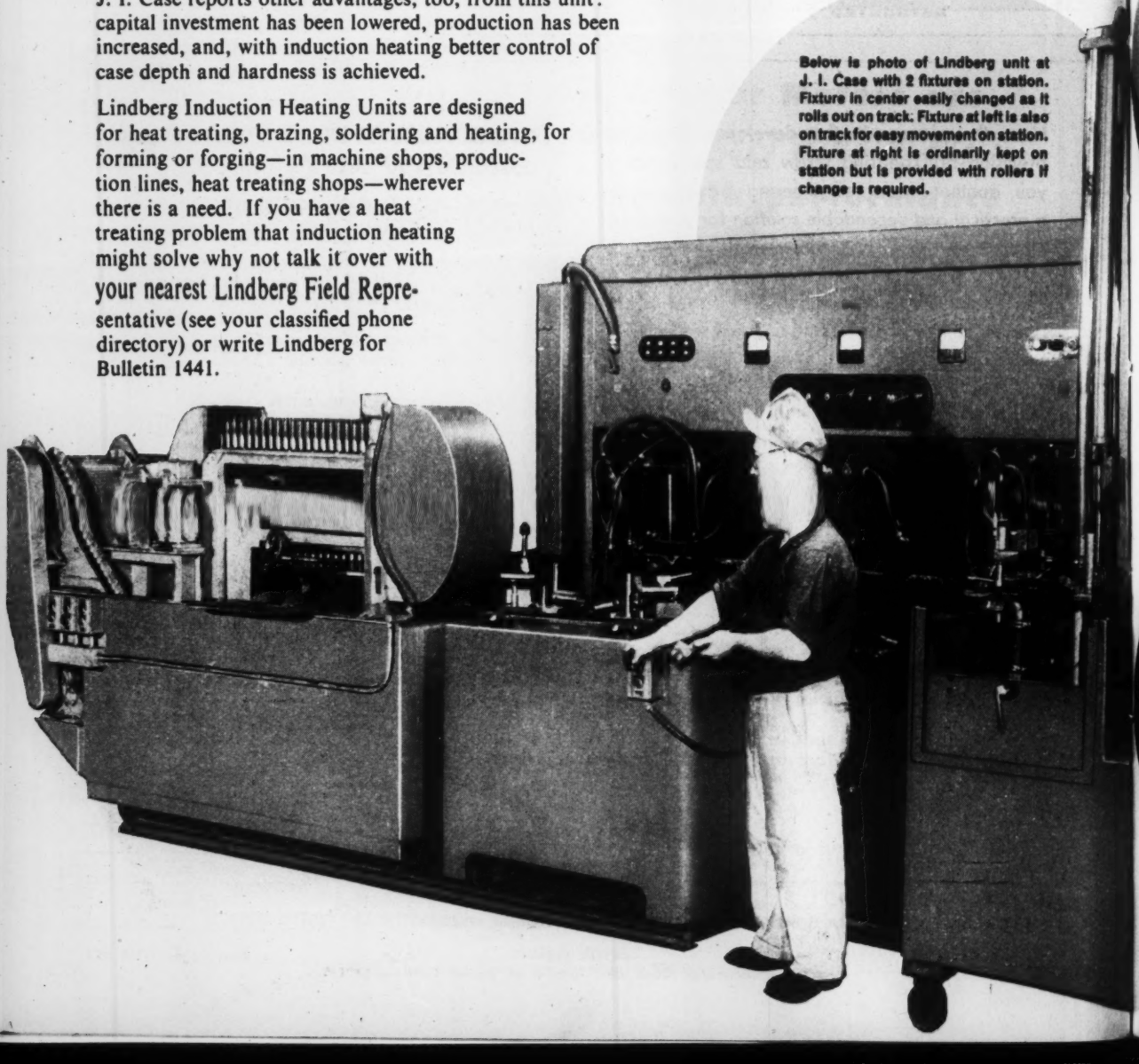
SAVES ½ ITS TOTAL COST— IN 1 YEAR!

A single Lindberg 2-station High Frequency Induction Heating Unit at J. I. Case Co., Racine, Wisc., is providing a happy combination of sizeable cost savings and improved quality and production efficiency in heat treating parts for Case tractors. Actually, the dollar savings effected with this Lindberg unit will repay its total original cost in *less than 2 years!*

This single unit and the five work fixtures provided with it, working on 2 to 3 shifts, 5 days a week to meet production requirements, heat treat some 63 separate tractor parts. Work fixtures are readily changeable, set-up time is materially reduced, and because of the 2-station design, the unit can operate continuously while work fixture is being changed over on one station.

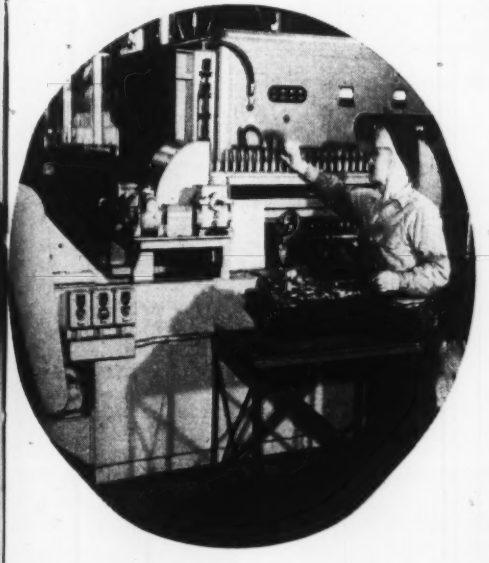
J. I. Case reports other advantages, too, from this unit: capital investment has been lowered, production has been increased, and, with induction heating better control of case depth and hardness is achieved.

Lindberg Induction Heating Units are designed for heat treating, brazing, soldering and heating, for forming or forging—in machine shops, production lines, heat treating shops—wherever there is a need. If you have a heat treating problem that induction heating might solve why not talk it over with your nearest Lindberg Field Representative (see your classified phone directory) or write Lindberg for Bulletin 1441.

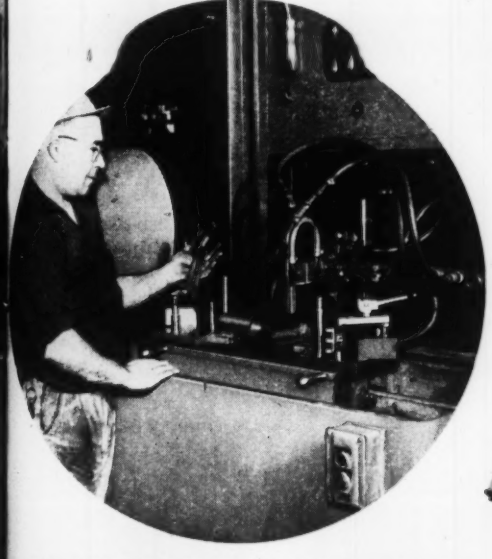


Below is photo of Lindberg unit at J. I. Case with 2 fixtures on station. Fixture in center easily changed as it rolls out on track. Fixture at left is also on track for easy movement on station. Fixture at right is ordinarily kept on station but is provided with rollers if change is required.

(Above) Hydraulic male coupling is being treated on this fixture. 3 other parts are treated by it, too.

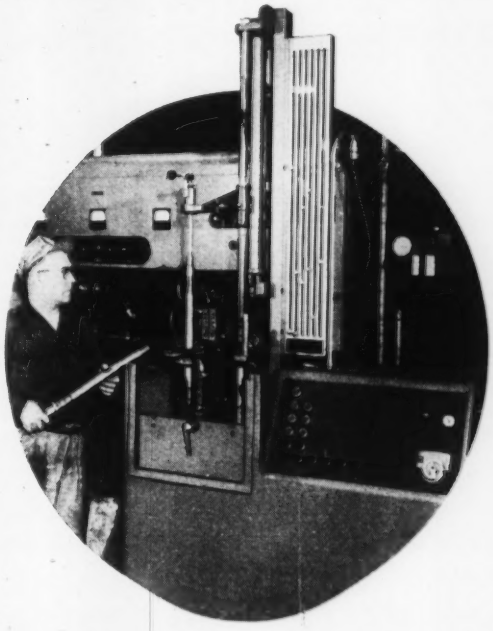


(Above) This shows fixture handling inlet and exhaust valve rocker arms. Same fixture treats 6 other parts.

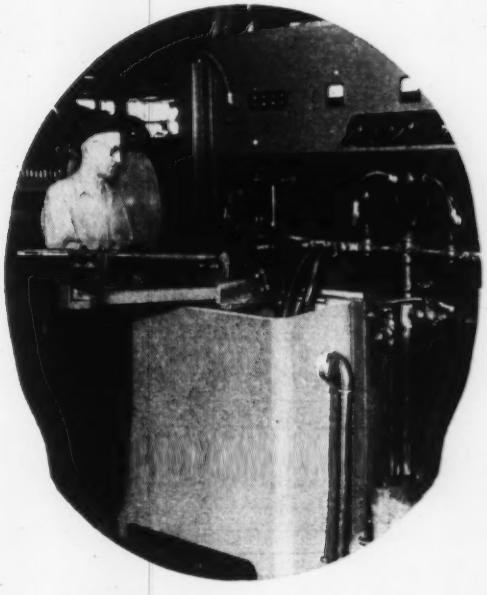


(Above) This fixture is selectively hardening pads and slots on shifter forks. It is also used for treating 17 other parts.

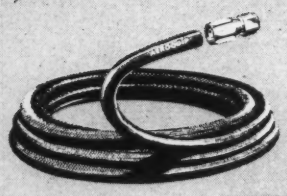
(Below) This fixture is shown selectively hardening a front axle king pin. It handles piece up to 45¼" long, 35" of which can be scanned to desired depth. It is also used for 34 other parts.



(Below) Power take-off hydraulic drive shafts are one of the 3 parts treated by this fixture.



LINDBERG
HIGH FREQUENCY DIVISION
Lindberg Engineering Company
2473 West Hubbard St., Chicago 12, Ill.



Designers' Guide for Selection of Hose Lines

EXCELLENT

GOOD

CONDITIONAL

UNSATISFACTORY

This hose selector chart plus other engineering data is included in Aeroquip Catalog No. 200. Write for your copy today.

TYPE OF FLUID	AEROQUIP HOSE NUMBER	1501	150101	1502 (Buna N)	1502 (Neop.)	1503 (Buna N)	1503 (Neop.)	1508	1509 (Buna N)	1509 (Neop.)	1509A (Neop.)	1513	1524	1525	1531	1532	1533 (Buna N)	1533 (Neop.)	1534	1538	1540	1541	1546	1547	2556	2650	2651	2750
Acetic Acid (conc.)		□	□	□	□	□	□	□	□	□	□	●	□	□	●	□	□	□	□	□	□	●	□	□	□	□	●
Acetic Acid (dil.)		□	●	●	□	●	□	□	●	□	□	●	●	●	□	●	●	□	●	●	□	●	●	●	●	●	●
Acetone		○	□	○	○	○	○	○	○	○	○	●	○	○	●	○	○	○	○	□	○	●	○	○	○	○	●
Acetylene		□	●	□	□	□	□	□	□	□	□		□	□	●	□	□	□	●	□	□	●	□	□	□	□	
Air		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Air, Hot		□	□	□	□	□	□	□	□	□	□		□	□	●	□	□	□	□	□	□	●	□	□	□	□	
Alcohols, Aliphatic		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ammonia, Anhydrous		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Ammonia, Aqueous		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Ammonia Gas		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Asphalt		○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	
Benzene (Benzol)		○	□	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	□	○	○	○	○	○	○	○
Butane		●	●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●	●		
Carbolic Acid (Phenol), Hot		○	□	□	○	□	○	○	□	○	○	□	●	□	○	□	○	□	□	□	○	□	□	□	□	●	
Carbon Dioxide (dry)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Chlorinated Solvents		○	□	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	□	○	○	○	○	○	○	○
Chlorine (dry)		▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	○
Chlorine (wet or solutions)		○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○		
Creosote Oil		□	□	□	□	□	□	□	□	□		□	□	○	□	□	□	□	□	○	□	□	□				
Diesel Fuel		●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●				
Ethers		□	●	●	□	●	□	□	●	□	□	○	●	□	□	●	□	●	●	□	□	●	□	□	□	○	
Freon 12, 13		□	●	●	□	●	□	□	●	□	□	□	●	□	□	●	□	●	□	●	□	□	□	●	□	□	●
Fuel Oil		●	●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●	●		
Furfural		□	□	□	□	□	□	□	□	□	□	○	□	□	○	□	□	□	□	□	○	□	□	□	□	○	
Gasoline, Refined		●	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●	●	●	○	●	●	●	●	●	○	
Gasoline, Sour		●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●				
Hydraulic Oil		●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●				
Hydrogen		●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●				
Hydrolube		●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●				
Kerosene		●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●				
Ketones		○	□	○	○	○	○	○	○	○		○	○	●	○	○	○	○	□	○	●	○	○	○			
Lacquers and Solvents		○	□	○	○	○	○	○	○	○	○	○	○	□	○	○	○	○	□	○	○	○	○	○	○	○	
Lindol, Cellulube		○	○	○	○	○	○	○	○	○		○	○	●	○	○	○	○	○	●	○	○	○				
Lube Oil (hot)		●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	●	○	●	●	●				
Mercury		●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●				
Mineral Oil		●	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●	●	●	○	●	●	●	○			
Naphtha		●	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●	●	●	○	●	●	●	○			
Naphthalene		□	□	□	□	□	□	□	□	□	●	○	□	□	●	□	□	□	□	□	●	□	□	□	○		
Natural Gas		●	●	●	●	●	●	●	●	●	●		●	●	○	●	●	●	●	○	●	●	●				
Oxygen		●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●				
Propane		●	●	●	●	●	●	●	●	●	●	○	●	●	○	●	●	●	●	○	●	●	●	○			
Pydraul F-9		○	○	○	○	○	○	○	○	○	○	●	○	○	●	○	○	○	○	○	●	○	○	○	○	●	
Steam		○	○	○	○	○	○	○	○	○	○	●	○	○	□	○	○	○	○	□	○	○	○	○	○	●	
Trichlorethylene		○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	□	○	○	○	○	○	○	○	
Toluene (Toluol)		○	□	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	□	○	○	○	○	○	○	○	
Water, Fresh and Salt (cold)		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
Water, Fresh and Salt (hot)		○	●	●	○	●	○	○	●	○	○	●	●	○	●	○	●	●	●	○	●	●	●	●	●	●	

Engineering assistance available to manufacturers.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 15, ONTARIO

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—ITEM 594—

For More Information Circle Item Number on Yellow Card—page 19

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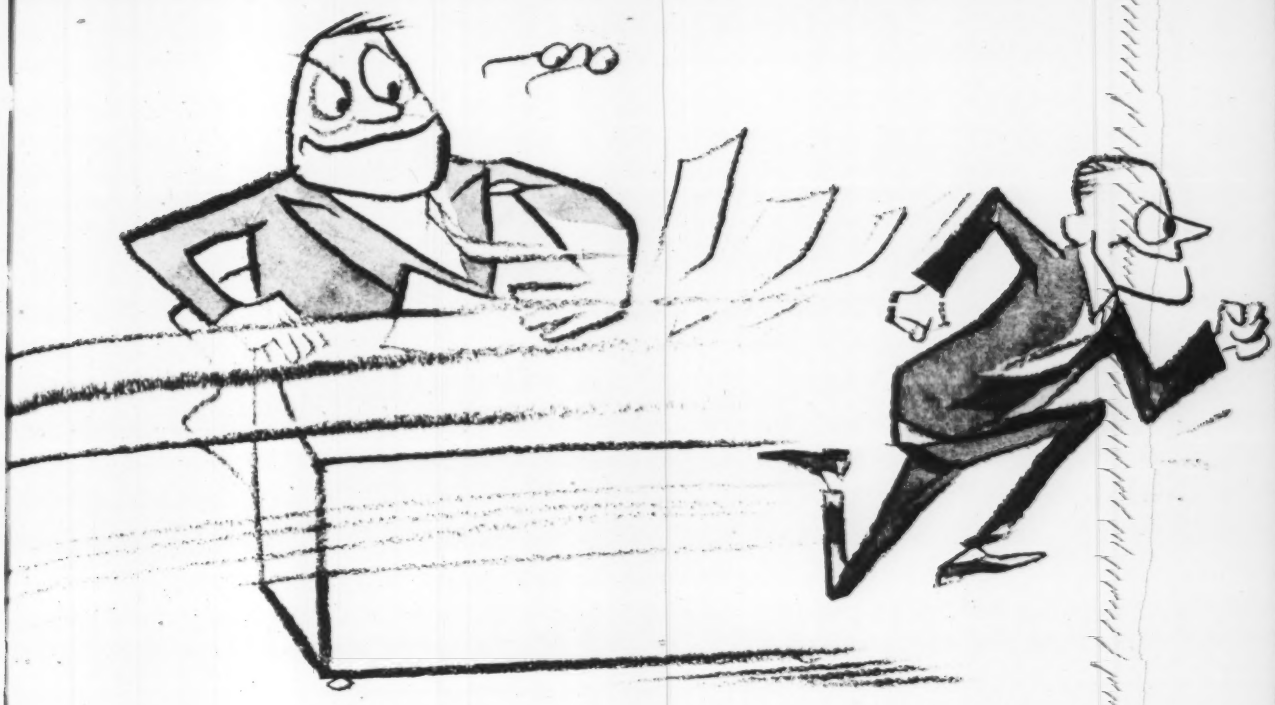


for young men who want to catch up to their bosses . . .

Alcoa's Up-to-Dater on Forgings

Four factual pages of news on the world's largest aluminum die forging, latest alloys, titanium, brass forging costs, hand forgings and other information for young men who want to catch up to their bosses.

Here's the world's largest

Forging history is being made as you read this. At Alcoa's Cleveland plant the world's largest closed die aluminum forging is being made. The part is a structural member for a jet bomber aircraft wing. It is 13 feet long, 3 feet wide, 12 inches thick. And it weighs 3,715 pounds. The die blocks weigh 60,000 pounds each. It is being forged on the giant 50,000-ton press operated by Alcoa for the United States Air Force.

Another example of what these giant presses save in machine time, man-hours and money is a jet bomber bulkhead. Alcoa was first asked to make it as an aluminum hand forging. We did, and it weighed 1,625 pounds. Redesigned, it was next made as a blocker-type forging on Alcoa's 15,000-ton press. It weighed 830 pounds. Now, here's the kicker. Redesigned again, the part was placed on the 50,000-ton press and squeezed out as a precision forging. This time it weighed 290 pounds! And imagine what happened to costs!

What does this illustrate? Simply that larger, more intricate forgings are a practical reality the way Alcoa makes them on the large hydraulic presses. Die life is lengthened. Draft angles drop from the customary 7° to 0°, in some cases. Machine time is cut dramatically. Thinner webs and ribs are possible. The actual forging, because it is squeezed instead of pounded,has smoother surfaces, less chance of surface defects, slivers and laps. And while you may never design a part that requires the facilities of our 15,000-, 35,000- or 50,000-ton presses, it's obvious that experience learned in solving problems like these can effect savings on your parts, regardless of the size and quantity. Let us prove it.

Need just a few? Need them in a hurry? Try hand forgings

Hand forgings come awfully close to what the blacksmith can beat out with an anvil and hammer. Except in Alcoa's shops,they grow to 2,500 pounds

Alcoa's Up-to-Dater on Forgings (continued)

and 300 inches long and 40 inches wide. Alert designers specify hand forgings when part requirements are few, or when designs are not final. In so doing, they avoid die costs and lost time.

This is old stuff to some, but we wonder if all designers realize that hand forgings can be had in far more intricate forms than the usual bars, slabs, biscuits, etc. And, further, they can be had in all the forging alloys.

The closer a hand forging approaches the shape of the finished part, the more metal and machining time is saved at your plant. Also, better mechanical properties come when the stock is forged to lighter sections. This extra quality is reflected in the strength of the finished part. But the dollars add up as a forging gets closer to the finished part. When does it pay? It depends on such things as machining costs, scrap wasted, work-load in your plant, properties necessary, etc. How to find out? Give your Alcoa sales engineer a sketch or drawing of the finished piece and an idea of the number needed. He will suggest the hand forging that might best serve your needs. Or, if you prefer, he will submit several propositions involving hand forgings ranging from the simplest shape to others coming closer and closer to your finished part.

We have just printed an informative, technical booklet, *Alcoa Hand Forgings*. Make sure you ask your Alcoa sales engineer for a copy. Or drop us a line.

Big news on small stuff

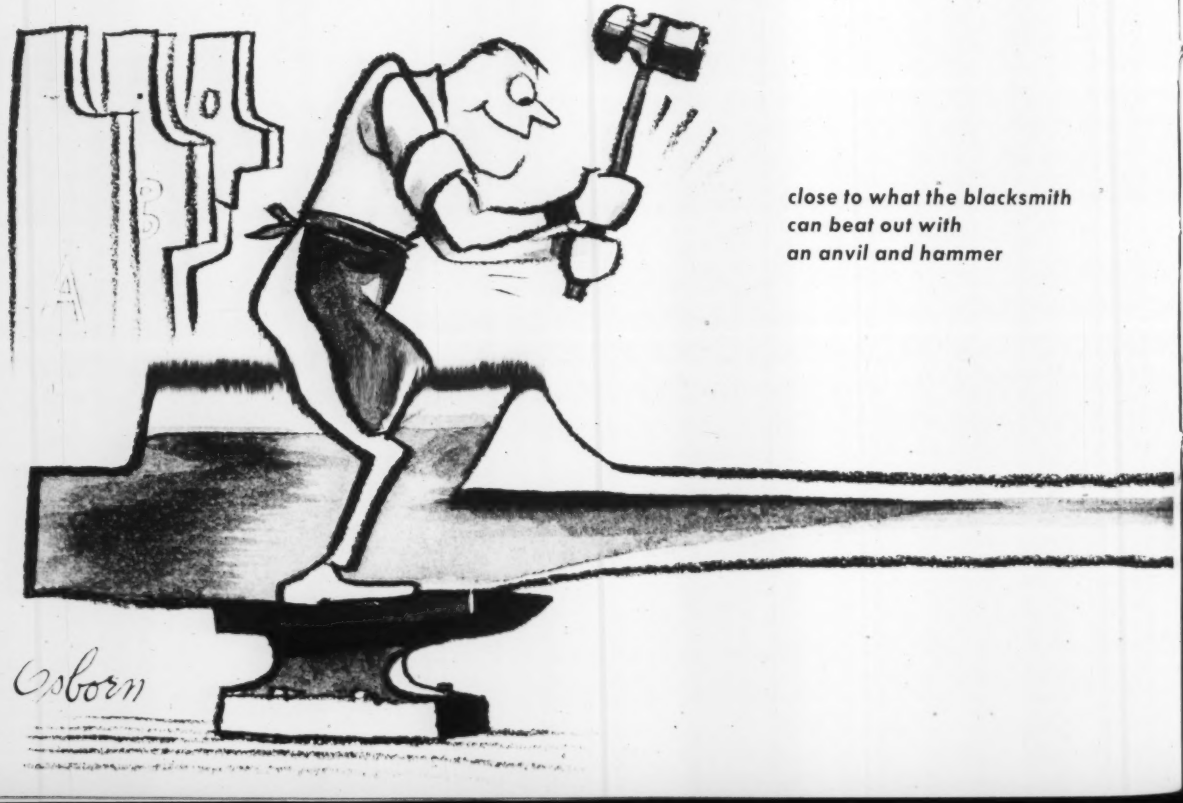
We often get so wrapped up in 50,000-ton presses and 2,500-pound hand forgings that we fail to mention a substantial part of your business and ours, i.e., small forgings. We operate a large percentage of our vast number of hammers and mechanical presses continuously on small forgings. These jobs are in our shops instead of somebody else's for one of several simple reasons: They cost less, and/or they're made better, and/or we deliver 'em faster, and/or we give more engineering service. It's the plain, unanodized truth that we can do the same for you. Let us quote.

The latest on titanium forgings

Titanium being the fourth most abundant structural metal in the earth's crust gives us more than a passing interest in the stuff. We don't make the basic metal sponge, or alloy it in ingots. But we are doing considerable development work in its fabrication that could easily accrue to your benefit. Titanium forgings are a case in point.

Being the country's largest light metal forging facility, we have equipment to do some remarkable things with titanium. Heavy-press capacity lets us forge it at optimum temperatures. This reduces the oxide film that forms at high temperatures and also results in better properties. Our pioneering work in no-draft forgings of aluminum plus superior die design work has helped us eliminate many problems of titanium forgings. These and other techniques, which we are keeping under wraps, permit us to offer titanium forgings at some mighty competitive prices.

Capacity now in operation can handle titanium forgings in sizes up to 30x60 inches. Deliveries run about the same as aluminum. Typical properties go something like this: 150,000 tensile, 140,000 yield, 15 per cent elongation.



close to what the blacksmith can beat out with an anvil and hammer

do some remarkable things with titanium

We see a lot in titanium beyond aircraft and ordnance. High-temperature processing equipment for corrosive materials is already a proven market for titanium forgings. Likewise severe marine applications. Now is the time to do some hard commercial planning with titanium. We'd like to help.

Buying brass forgings? Why?

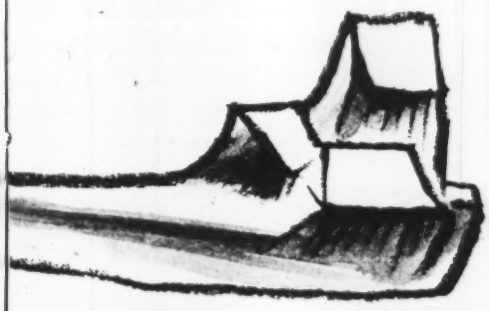
"Why"—since aluminum costs one-sixth as much as brass?

"Why"—since aluminum has become so easy to forge?

We don't expect these simple facts to undermine the foundations of the brass forging industry. But they are particularly pertinent in these competitive days. We don't mean to imply that every part now forged in brass would be less costly in aluminum. But the plain truth is that if more users of brass forgings would ask themselves "Why," there'd be a whopping lot of money saved.

A tour through Alcoa's forge plants will show aluminum forgings such as valve and pipe fittings, luggage hardware and many other parts that used to be brass. They are now aluminum for one main reason only. Cost. Yet it is equally true that these users have gained more than money. Their products are lighter—about half as heavy for equal strength. They are rustproof. They can be colored any shade of the spectrum right in the metal surface. They conduct heat and electricity like—well, like brass.

If you have an inkling that your brass part might cost less in aluminum, let us inkle with you. The difference could be considerable, and the consultation is painless and free.

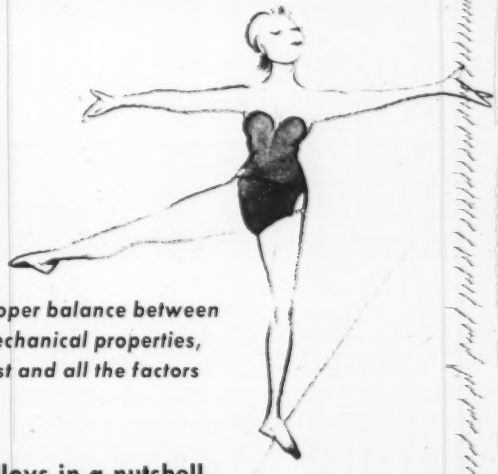


About quality control

This is something that everyone talks about, and few have to a degree that makes it really worth while. Usually the palaver goes something like this: "Every step is closely guarded by standards of rigid quality control, using utmost skill and the latest methods of inspection."

Next time you hear something like that, get the specifics and check them against Alcoa's tally: Ultrasonic inspection, fluorescent penetrant inspection, destructive testing, sectional testing for grain flow, Brinell tests, plus hundreds of visual checks and inspections throughout the process.

There's a difference.



proper balance between mechanical properties, cost and all the factors

Alloys in a nutshell

Maybe the toughest nut in designing for aluminum forgings is picking the right alloy. On the next page is a skeleton table along with brief comments about each alloy. Note alloys X-7079 and X-2219, just announced a few months ago. Alloy X-7079 is a new high-strength deal like 7075. But it provides a higher level of short transverse elongation plus being less apt to distort on machining. Alloy X-2219 offers a lot of new features for problems in 500-600°F range. There's lots more to the alloy story and we think your Alcoa salesman is the right man to help you get the proper balance between mechanical properties, costs, and all the factors that go into the picking of the alloy that's exactly right for your job.

Alcoa's Up-to-Dater on Forgings (continued)

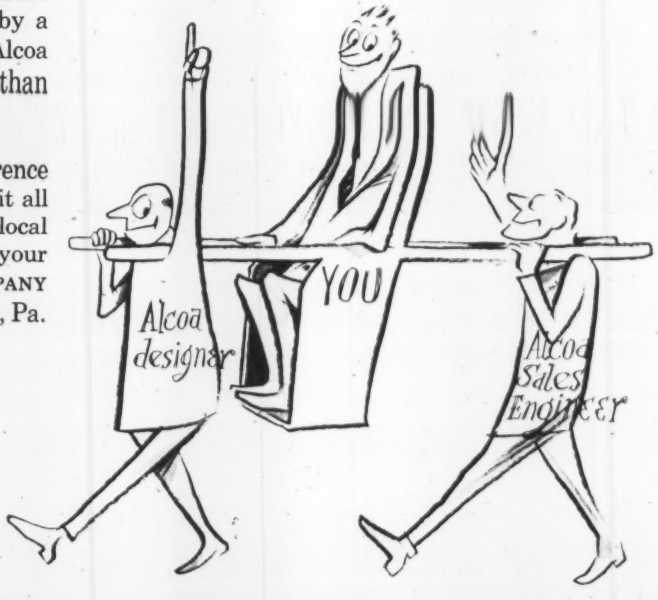
MECHANICAL PROPERTIES OF ALCOA® ALUMINUM FORGINGS

ALLOY	MINIMUM SPECIFICATION VALUE (1) TENSILE STRENGTH	YIELD STRENGTH	ELONGATION % in 2"	TYPICAL VALUES (1) TENSILE STRENGTH	YIELD STRENGTH	ELONGATION % in 2"	BRIEF ADVANTAGES OF ALLOY
2014-T6	65,000	55,000	10	70,000	60,000	13	readily forgeable, high strength.
X-2219	55,000	35,000	6	62,000	43,000	16	high strength in 500-600°F temperature range.
6151-T6	44,000	37,000	14	48,000	43,000	17	good mechanical properties, readily forgeable.
7075-T6	75,000	65,000	10	82,000	72,000	11	highest strength.
X-7079	74,000	64,000	10	78,000	68,000	14	high strength, improved ductility in transverse, less quench sensitive.
4032-T6	52,000	42,000	5	55,000	46,000	9	high strength at elevated temperature. Selection between these three alloys depends on individual requirements.
2218-T72	38,000	29,000	8	46,000	36,000	10	
2018-T61	55,000	40,000	10	62,000	48,000	12	
6061-T6	38,000	35,000	10	45,000	40,000	17	superior welding and brazing qualities, readily forgeable, corrosion resistant.
2025-T6	55,000	33,000	16	58,000	37,000	19	special-purpose propellers, etc.

(1) For forged sections to 4" thick for all alloys except 7075-T6 which is 3" and X-7079 which is 6".

Straight talk

In these days of designing for sales as well as performance, many a designer has found a competitive edge in Alcoa Forgings. This often comes about through solid technical thinking contributed by a local Alcoa sales engineer and a designer in Alcoa forge shops. It is this help, perhaps more than machines and equipment, that makes the difference in dealing with Alcoa. And the practicality of it all is that it's free. Your first step is to call the local Alcoa sales office listed under "Aluminum" in your classified phone book. Or write, ALUMINUM COMPANY OF AMERICA, 1994-F Alcoa Bldg., Pittsburgh 19, Pa.



Your Guide to the Best in Aluminum Value

ALCOA ALUMINUM FORGINGS
ALUMINUM COMPANY OF AMERICA

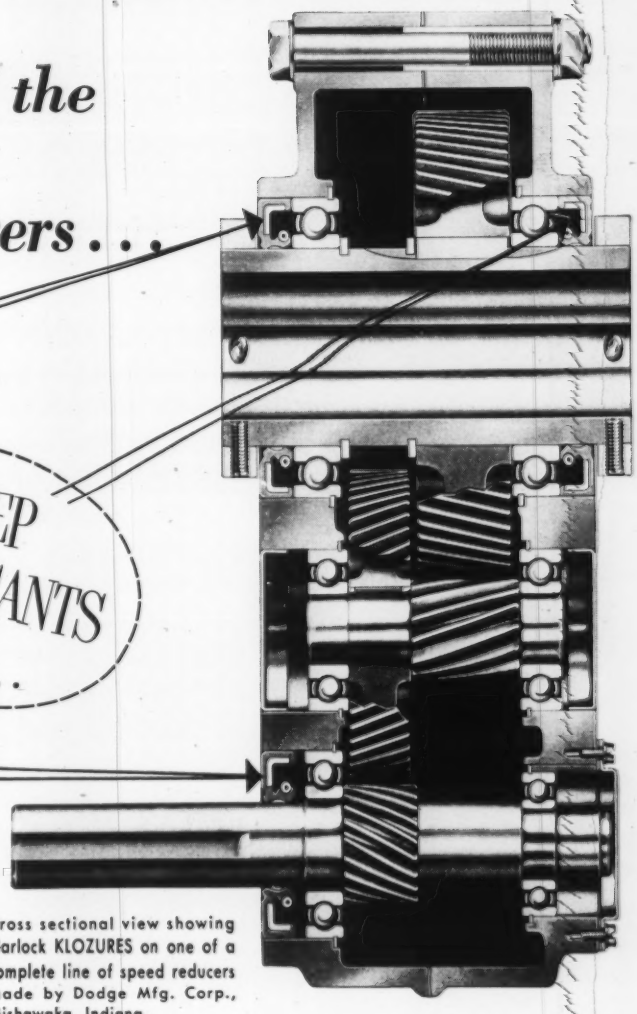
Litho in U.S.A.

Over half the speed reducer manufacturers . . .

KEEP DIRT OUT . . .

KEEP LUBRICANTS IN . . .

WITH **KLOZURE*** **Oil Seals**



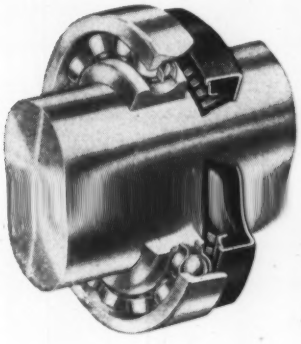
Cross sectional view showing Garlock KLOZURES on one of a complete line of speed reducers made by Dodge Mfg. Corp., Mishawaka, Indiana.

Makers of such fine precision products as The Dodge Torque-Arm Speed Reducer will not compromise when specifying oil seals. They know that the reputation of their entire product may depend on the quality of the oil seals they put in it.

Think about this the next time you have occasion to specify oil seals, and we think you'll choose Garlock KLOZURE Oil Seals—guaranteed to do the job you specify with minimum power loss and heat generation.

KLOZURES are available in a complete range of types and sizes. Therefore, be sure to call in one of Garlock's 125 trained sales engineers right at the start. His experience will save you time and money. Or, write today for Catalog No. 10.

**Registered Trademark*



Model 53 finger spring KLOZURE for normal and high speed service, applied to a shaft to protect the ball bearing.

THE GARLOCK PACKING COMPANY, Palmyra, New York

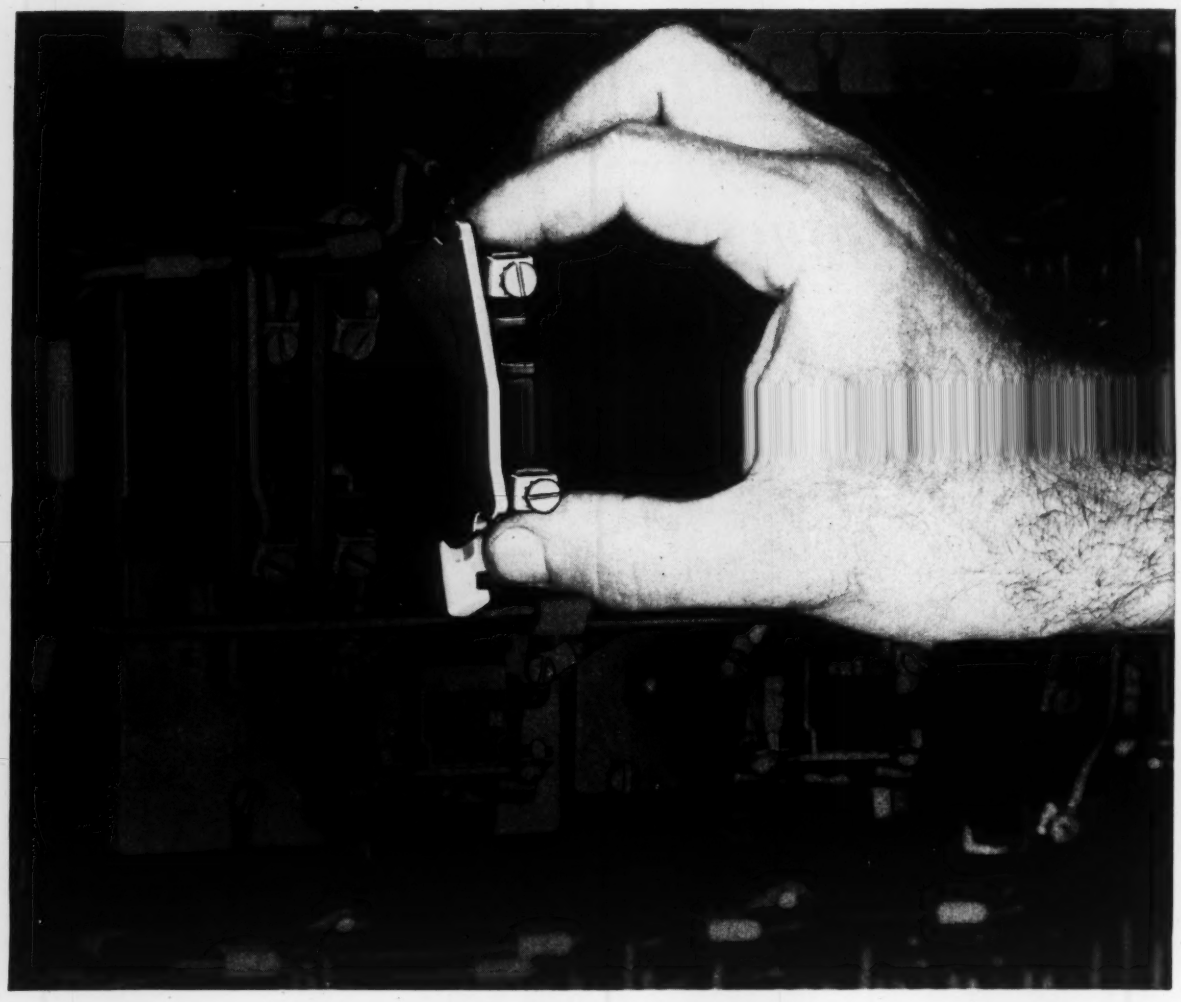
For Prompt Service, contact one of the 30 sales offices and warehouses throughout the U. S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

—ITEM 596—

For More Information Circle Item Number on Yellow Card—page 19

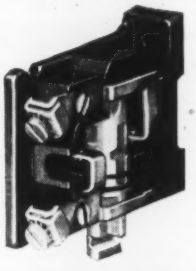


You can easily remove a single pole from any CLARK Type "PM" Relay

Each pole in the new CLARK heavy-duty relays is an integral unit that can be quickly removed or replaced *from the front* without disturbing other poles. You need disconnect only two wires and loosen one mounting screw—regardless of the number of poles in the relay. Compare this with other types of relays where the whole device must be removed to accomplish the same thing. For example, with a conventional 6 pole relay, 14 wires and 3 mounting screws must be removed.

All terminals are located on the front. They are "pressure" type, eliminating need for looping wire. Coil-changing and magnet replacement can also be done quickly from the front without removing relay from panel.

Write for Bulletin PL-7305



Each pole is contained in its own melamine housing.

A short circuit through one set of contacts is confined to a single pole and will not destroy the whole relay. Enclosed top protects from dust and dirt, and serves as wiring shelf.

The **CLARK CONTROLLER** *Company*

Engineered Electrical Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

—ITEM 597—

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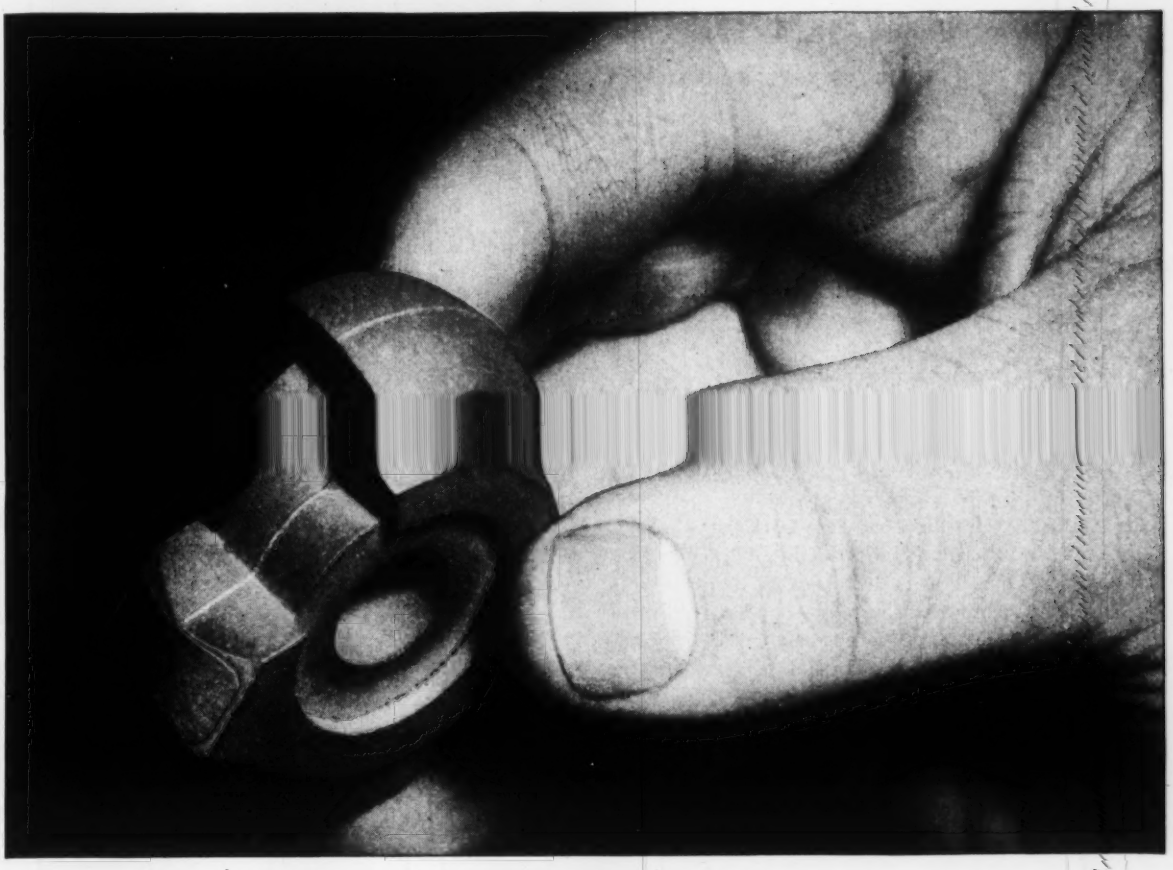


How precision casting cut costs 84%

on this small part

Camco, Inc., of Houston, Texas, specializes in oil field equipment.

They produce a gas lift valve which can be installed in, or removed from, an oil well without pulling the tubing.

Inside the valve is a latching cam to lock it in place. And that little part caused Camco expense and trouble — until they came to Inco.

The part had to be resistant to oil well corrosives — strong to take the pressures — hard so that it wouldn't gall, seize or change shape despite years of exposure to corrosion, abrasion, shock and pull.

One metal they tried was hard enough, but too brittle. And costs to machine the part from bar stock seemed out of line.

Camco, already using Inco Nickel Alloys — Monel* nickel-copper alloy and "K"* Monel age-hardenable nickel-copper alloy — for other parts of the valve with good results, decided to consult Inco on this one.

Inco engineers recommended precision investment castings in "S"* Monel hard-grade nickel-copper cast alloy.

The price of the finished cam, including the cost of drilling and lapping, cut Camco's cost on this part 84 per cent!

Can You Cut Costs with Inco Precision Castings?

Whenever you have a part which is 6 inches x 5 inches or smaller, weighs under 3 lbs., requires starting tolerances as close as plus or minus .005 inch per linear inch, and needs 5 or more fabrication steps, there's a good chance you can save by having it precision cast.

What Alloys Can Be Precision Cast?

You may obtain precision castings from Inco in many metals and alloys, from plain carbon steel to the new super alloys. And no matter what metal you specify, you get many advantages.

Seven Advantages of Precision Casting

Precision castings may save as much as 60 per cent of production costs. (Savings like Camco's are unusually high.) They also make possible the use of extremely hard metals. Reduce machine shop bottlenecks. Lead to economies through redesign. Reduce metal scrap. Often permit the use of a higher alloy which otherwise would be too costly. Even make possible designs you previously thought impractical to produce.

*Registered Trademark

Get This Helpful New Booklet

Trying to keep costs in line on some small part? Then write for new 16-page booklet, "Cast to Outlast." Contains many case histories detailing how others cut costs with Inco precision castings. There is a good chance this helpful data will suggest a practical way to cut your costs, too.

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

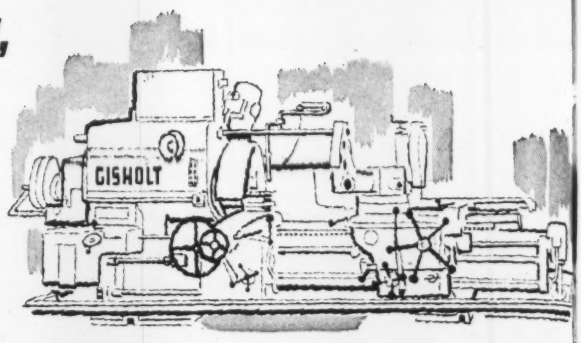
INCO
TRADE MARK

Inco Castings

. . . Precision, Sand, Centrifugal

WHY GISHOLT SELECTED THE NEW "SF" ELECTRIC CLUTCH ORIGINATED BY WARNER

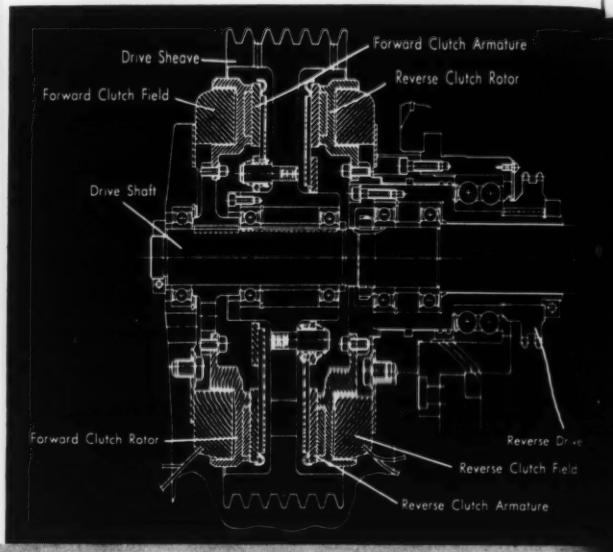
New drive improves control, saves motor maintenance!



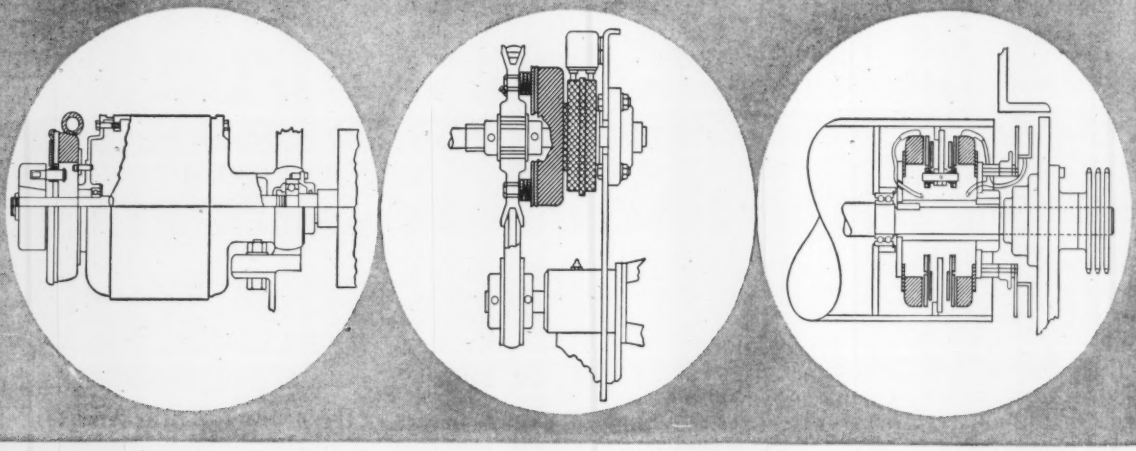
Here's a unique and extremely simple design—one constant running drive motor belted to a constant speed drive sheave, and two Warner Stationary-Field Electric Clutches accomplish all functions of starting, stopping, reversing, and jogging the spindle of this Gisholt Turret Lathe. Benefits to Gisholt users are many, including simpler control of actuating elements . . . precise inching control of the chuck . . . fast reversing . . . and reduced loading on the drive motor.

Get the jump on competition by doing as hundreds of America's leading equipment builders are doing today . . . using Warner "RF" Electric Brakes and "SF" Electric Clutches to increase machine performance and facilitate automatic control. With simple magnetic circuits . . . thicker and tougher friction surfaces and more compact design . . . these new Warner units give you all the revolutionary control advantages made possible by electro-magnetic actuation . . . plus more of the dependable, trouble-free operating features your customers want to increase their production and control their costs.

Now in production and ready for delivery to you in capacities from 125 to 700 lb ft, maximum static torque ratings.



EASILY SOLVE POWER PROBLEMS LIKE THESE



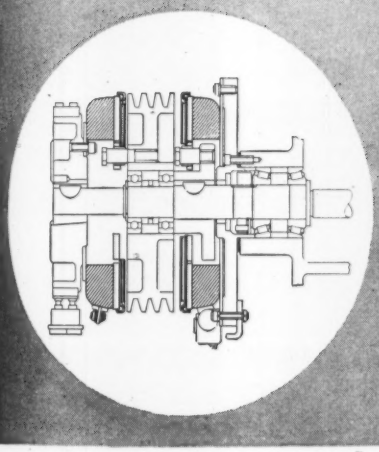
Textile Machine—Brake magnet is stationary mounted to motor housing. Armature is mounted on drive pins to hub, which is keyed to a shaft which drives the brush roll. Perfectly synchronized stopping of eight rolls is accomplished by adjustment of individual rheostats in the control panel. Tearing and piling up of material between rolls has been eliminated while stopping the machine.

Mobile Power Unit—Electric clutch armature is mounted on three drive pins to a free-running sheave, driven from the prime mover. The field and collector ring assembly are keyed to the driven shaft through a hub and taper-lock bushing. Actuation of a conveniently positioned remote control switch energizes the field, which locks with the armature and engages the pump drive.

Guillotine Cutter—Two clutch armatures are mounted back-to-back on drive pins extending through a spider inside the drum. Current is supplied from a slip ring to clutch fields, which are mounted to a hub on the drive shaft. Clutches are actuated simultaneously by a rotating crank, controlling drum drive and conveyor feed. Adjustment of crank throw controls size of material cut.

Precise inching of the spindle is controlled by applying reduced current to the forward drive clutch field.

When the forward drive clutch is operating and the reverse clutch is energized, the reverse clutch acts momentarily as a brake to decelerate the spindle, and then as a clutch to accelerate it in the opposite direction. The braking action is extremely fast, and the acceleration is exceptionally smooth.



Machine Tool—Free running sheave is used as mounting hub for clutch armature. Clutch magnet is mounted to collector ring assembly and keyed to headstock spindle. Brake magnet is stationary-mounted to machine casting, while armature is mounted on pins set in hub, which is keyed to spindle. Fast switching from clutch to brake permits improved inching and jogging, easier control.

Beat competition with

ELECTRIC BRAKES AND CLUTCHES

Warner Electric Brake & Clutch Co.
Dept. MD, Beloit, Wisconsin

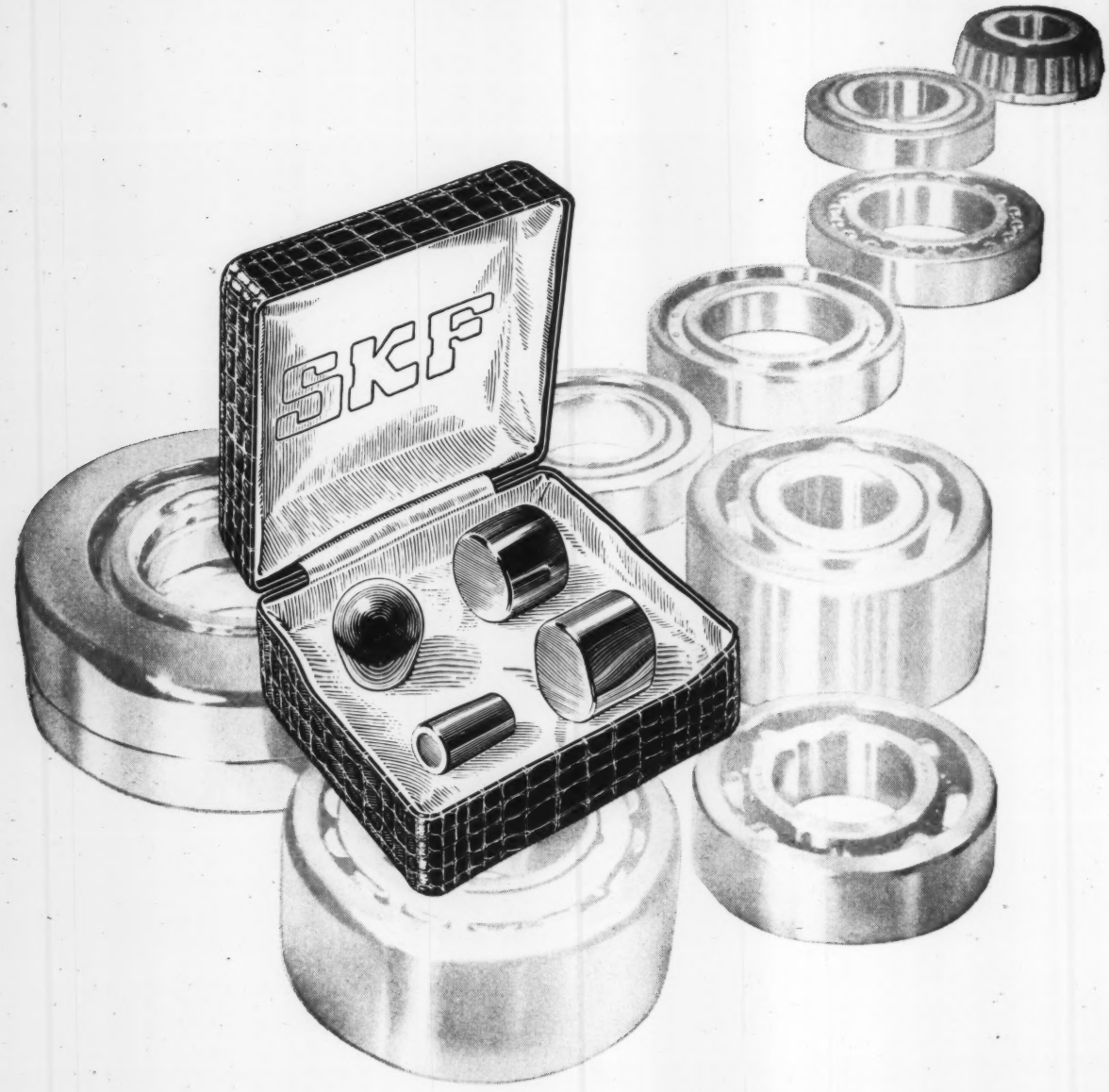
Please send copy of your new Condensed Catalog No. 6212.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____



SKF Has Them All

If you want to be *sure* you are putting the right bearing in the right place in your product, check with SKF—the *one* bearing manufacturer selling all four major types of anti-friction bearings. From this single source, you quickly and easily get unbiased advice based on the broadest experience in the anti-friction field. **SKF INDUSTRIES, INC.**, PHILADELPHIA 32, PA.

7710

SKF

Ball Bearings Cylindrical Roller Bearings
Spherical Roller Bearings Tyson Tapered Roller Bearings

—ITEM 600—

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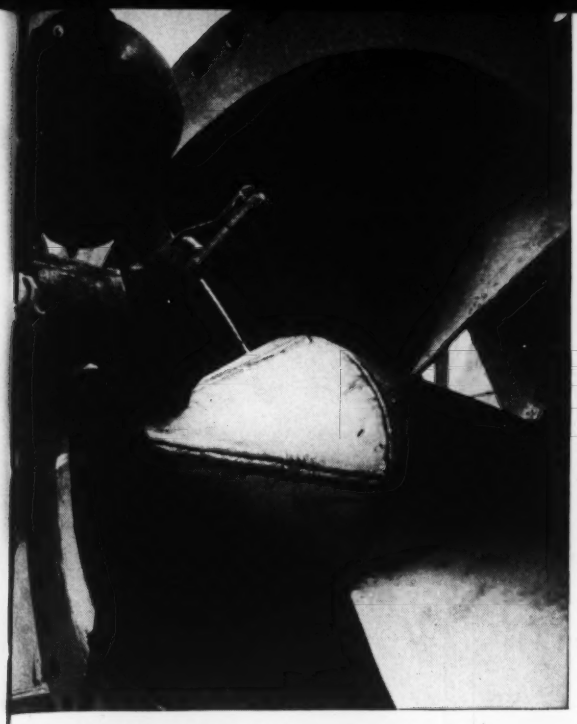
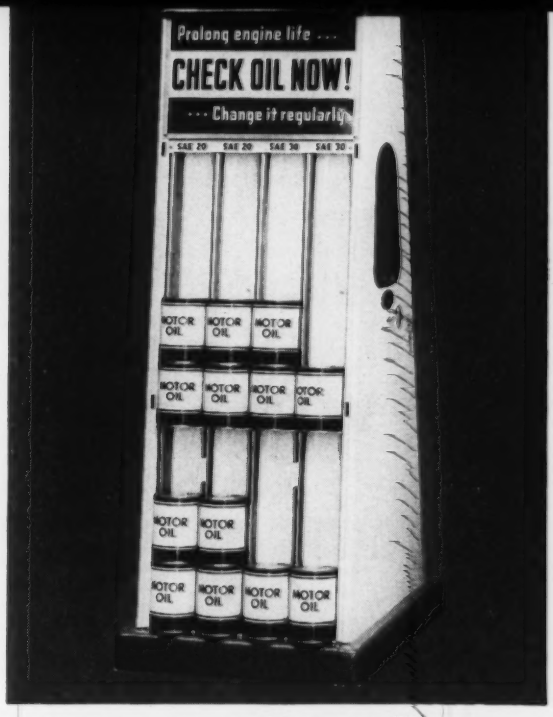
Facing Page—ITEM 601→



FOR COMPLEX FABRICATION. In chemical plants, these Stainless Steel acid catchers are used to remove dilute sulfuric acid from gases. Continental Boiler & Sheet Iron Works in St. Louis fabricated the units. Notice the complicated curves in the helix plates, and the neat joinery . . . a tribute to fine craftsmanship and the workability of Stainless Steel.



FOR ABRASION AND CORROSION RESISTANCE. Oil can racks stand out in all kinds of weather, and the support strips are constantly rubbed and knocked by the heavy cans of oil. Modern Metal Products Company of Greensboro, N. C. makes the strips out of Stainless Steel so they will stay bright and new-looking, and never get banged out of shape.

NOTHING *can equal* *Stainless Steel*

In its combination of desirable properties

FOR SANITATION. These Stainless Steel shelves are made by the Eastern Steel Rack Company, Boston, Massachusetts, for use in cold storage rooms. They are easy to clean, and offer a sanitary, corrosion-resistant surface for food products of all kinds.

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When seeking a source of supply, remember that United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

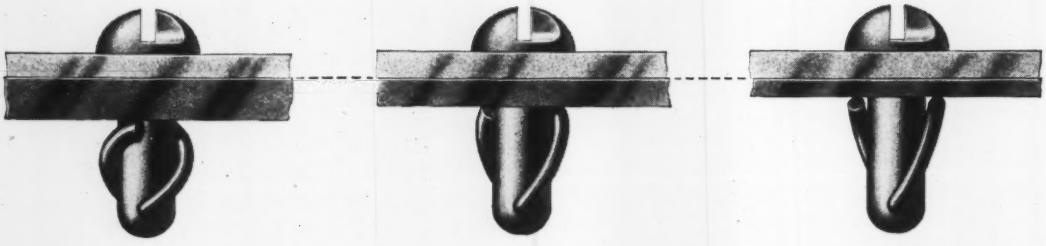
USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

This fastener works through thick and thin!



Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

SIMMONS FASTENER CORPORATION

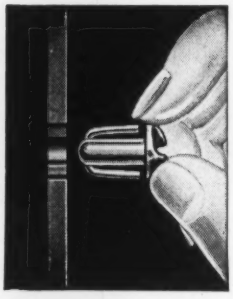
1756 North Broadway, Albany 1, New York

Simmons

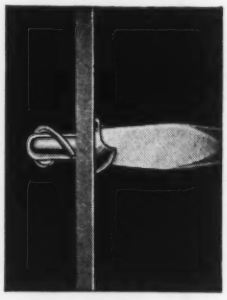
QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

HERE'S HOW SPRING-LOCK WORKS



1. *Insert fastener.*



2. *Half-turn locks it in place.*

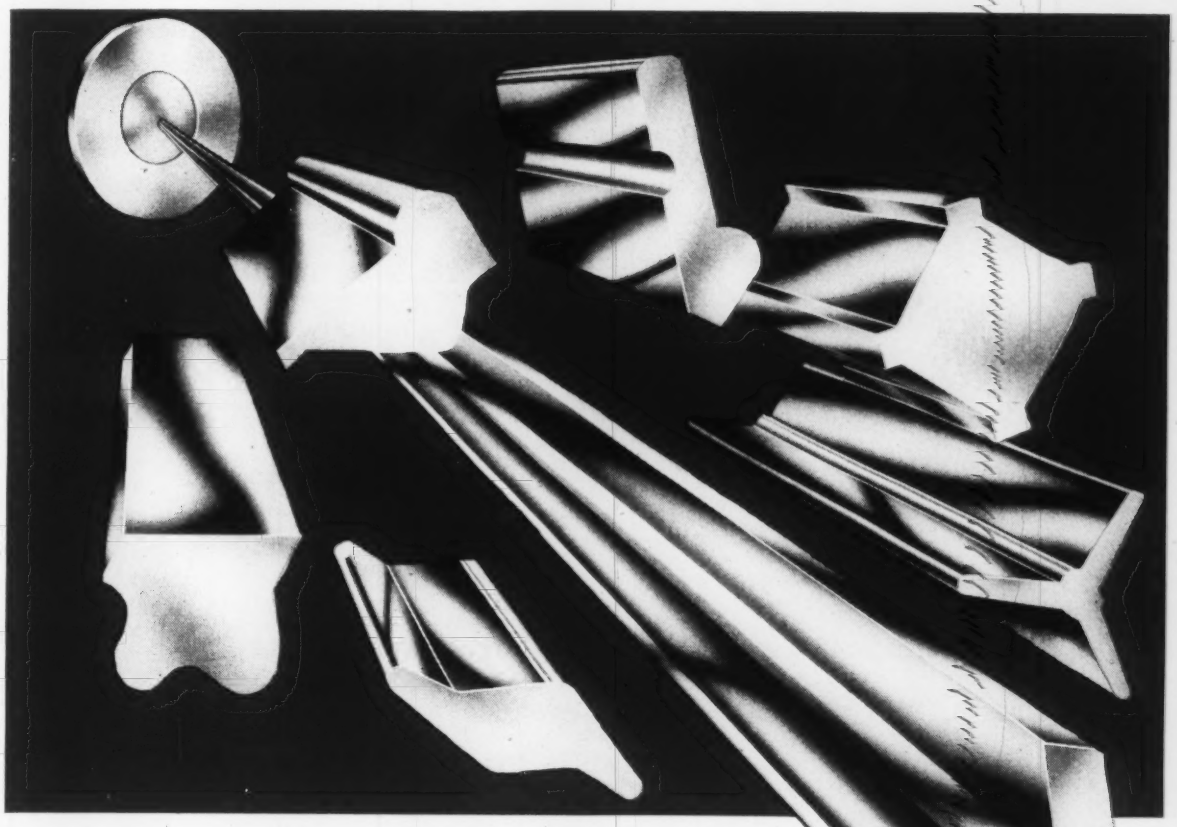
With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.

—ITEM 602—

For More Information Circle Item Number on Yellow Card—page 19



J&L custom-made hot extruded cold drawn sections... boost production, cut over-all costs

Progressive industry is today utilizing J&L's Custom-Made, Hot Extruded Cold Drawn Steel Sections to:

1. **Eliminate time and costs** in machining and finishing operations
2. **Reduce scrap losses** practically to the zero point
3. **Eliminate the cost of castings and forgings** of intricate sections requiring considerable machining
4. **Reduce inventories** due to quick availability of extruded sections from the J&L plant

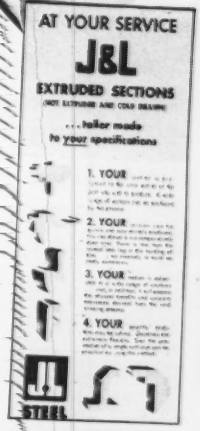
These sections can be extruded and cold drawn to the exact specifications of the parts you require — in any quantity you specify. Even the production of a single extrusion can be economical. Obtainable in a wide range of material grades, J&L Extruded Sections can be produced in a large variety of shape profiles — within limits of a design which can be inscribed within a two-inch circle. Many shapes that cannot be hot rolled are practical for the extrusion process.

The mechanical properties of J&L Extruded Sections are equal to or superior to those obtainable from equivalent grades conventionally cold drawn. Cold drawn tolerances are accurately maintained. The excellent surfaces of these Extruded Sections require little — if any — finishing operations.

Send us your inquiry for prompt and efficient J&L service.

J&L STEEL

Write today for your copy of this free new booklet which gives detailed information about the many money- and time-saving advantages J&L Extruded Sections offer you.



Jones & Laughlin

STEEL CORPORATION · PITTSBURGH

Jones & Laughlin Steel Corporation
3 Gateway Center, Dept. 410, Pittsburgh 30, Pa.

Please send me your new Booklet on *Extruded Sections.*

Name_____

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Company_____

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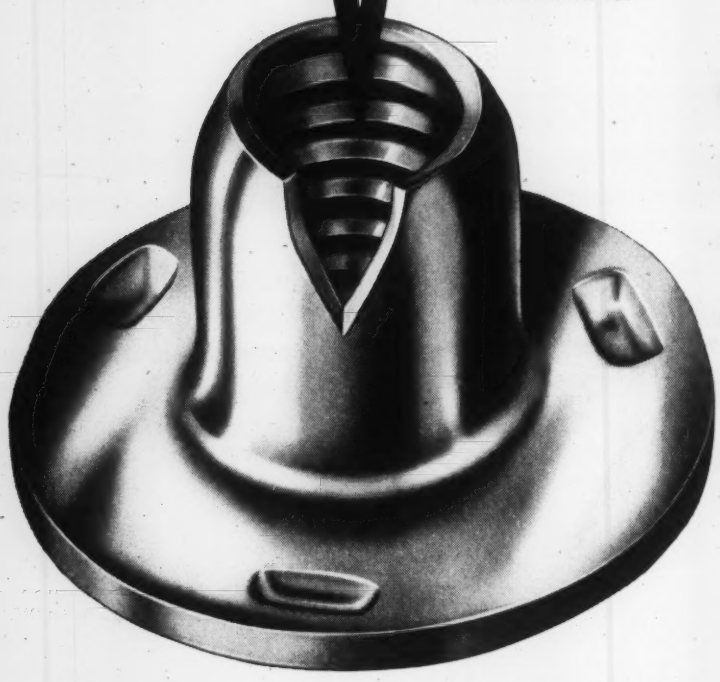
—ITEM 603—

For More Information Circle Item Number on Yellow Card—page 19

NEW V-LOCK TEENUTS®

PATENT APPLIED FOR

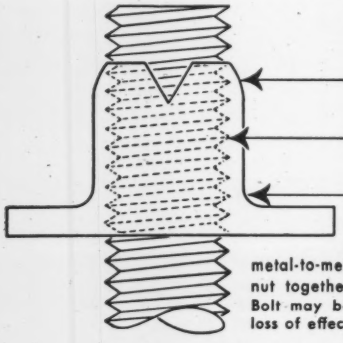


- self-locking
- vibration-proof
- one-piece construction
- proven effectiveness
- highly adaptable
- re-usable

The upper portion of this precision-made Teenut incorporates a V-type notch with the circumference of the barrel compressed inwardly toward the axis to form a permanent set. This makes it a re-usable, prevailing-torque-type, self-locking nut.

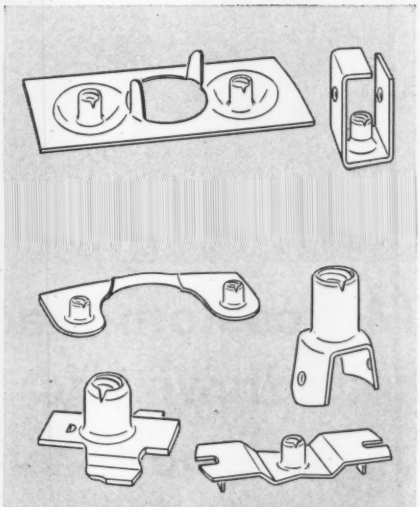
It is a one-piece, self-contained unit in which the self-locking device is an integral part of the design. No non-metallic materials or stamped parts are used so that the V-lock Teenut is not affected by heat or oils and has high tensile strength.

As the V-lock Teenut does not rely on base load to obtain its friction grip, it may also be used as a stop nut. (Indentations in base flange are welding bosses).



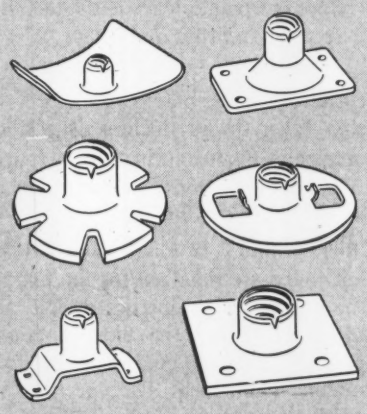
Bolt spins freely into nut until it reaches gripping area. Then, spring action creates strong, metal-to-metal wedging force, locking threads of bolt and nut together to make assembly virtually vibration-proof. Bolt may be removed and replaced many times without loss of effectiveness in nut.

The V-lock Teenut is but one of thousands of special purpose fasteners designed and manufactured by United-Carr to help speed assembly, cut costs and improve product performance. For further information on the V-lock Teenut or for help with any other fastening problem, consult your nearest United-Carr field representative or write us for his name and address.



UNLIMITED VARIETY

V-lock Teenuts can be engineered in various shapes and sizes to suit customer's specifications. Can be manufactured *in volume*... in brass, bronze, stainless steel, aluminum, etc.... with unified screw threads, class 2B, in both coarse and fine thread series. Finishes: zinc, cadmium, chrome, parkerized, etc. to customer's specifications.



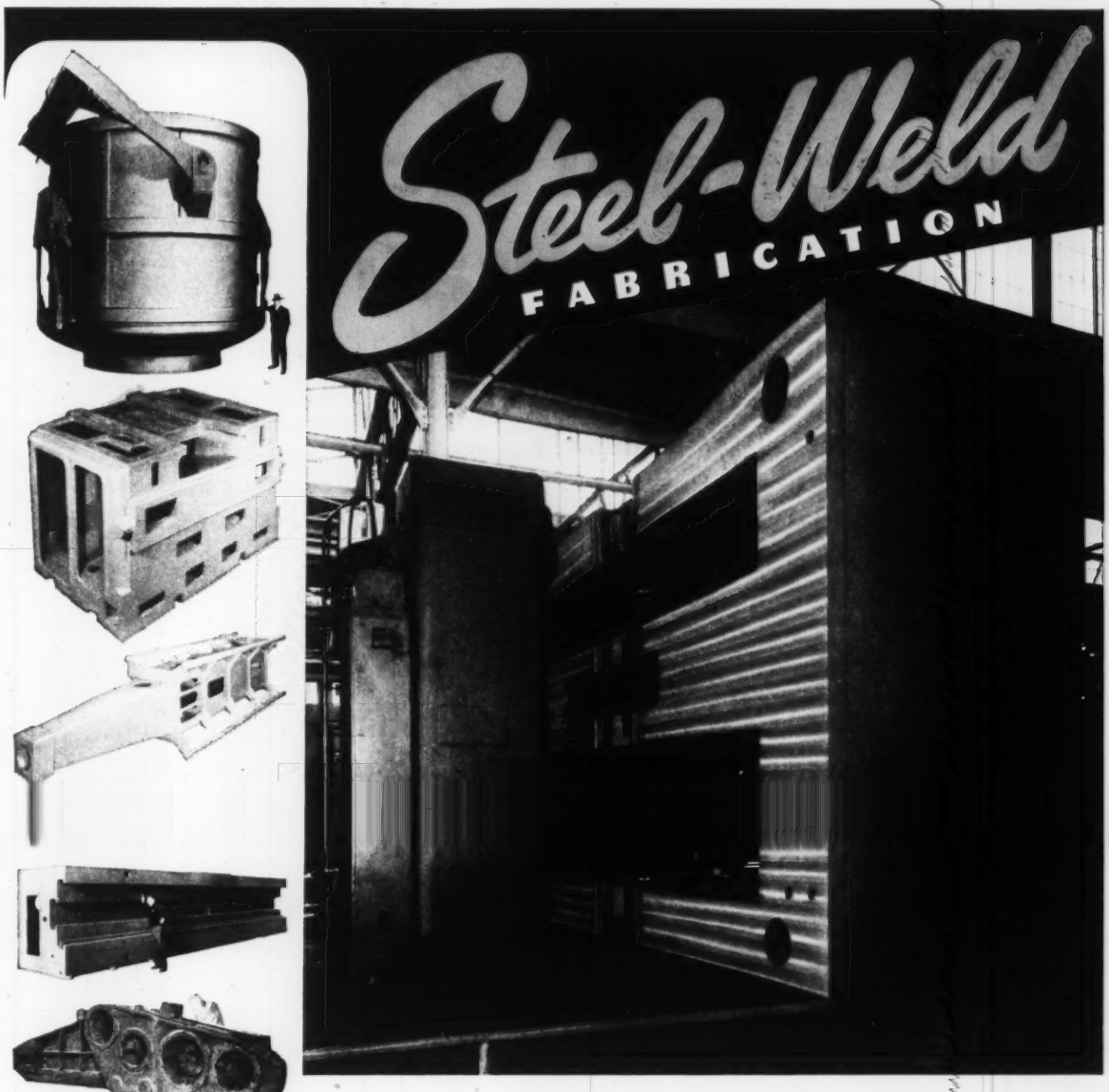
UNITED-CARR FASTENER CORPORATION

31 Ames Street Cambridge 42, Mass.

MAKERS OF DOT FASTENERS

SEE US AT BOOTH 511, DESIGN ENGINEERING SHOW

—ITEM 604—



The 65-ton weldment above is the crown for a large press. This piece, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are YOU making full use of welded steel components in your products? In the design of almost any type of heavy machinery there are pieces and sub-assemblies that can be produced more economically in welded steel—and with the additional advantages of less weight, greater rigidity and predictability. When you consider weldments, think of Mahon . . . because, you will find the Mahon organization a unique source of supply for welded steel in any form . . . a source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or, better still, have a Mahon sales-engineer call at your convenience.

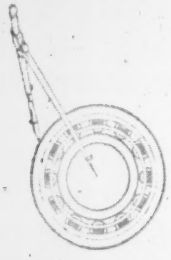
THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

Cylindrical Roller Bearing Retainers . . .



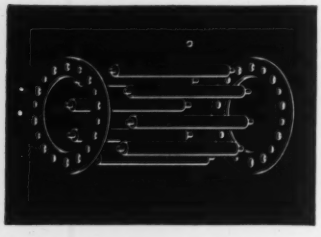
The seven basic types in current use . . . their influence on bearing cost and performance . . . why one type is best suited to your individual design requirements

Most cylindrical roller bearings consist of an inner race, an outer race, a complement of rollers, and a cage or separator which locates and guides the rollers. There are significant differences in the design and construction of these roller retainers. (The word "*retainer*" is used to designate both a cage, which retains the rollers, and a *separator* which only spaces the rollers.) Some retainers are simple and economical, well adapted for volume production, and designed for use where price is a primary consideration. Others are more costly to make but are designed for improved roller guidance, to insure cooler or smoother operation, or to provide longer life in heavy duty service.

Beginning with the most elementary, here are the seven basic types of cylindrical roller bearing retainers in current use, with a brief outline of their construction and characteristics:

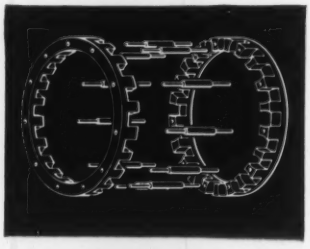
1. TRUNNIONED ROLLER CAGE

The trunnioned roller cage is used for bearings of very thin annulus, where the rollers must be small in diameter, closely spaced, and relatively long. The end rings are economical hardened steel stampings, into which the trunnioned rollers are inserted. The bars which connect the end rings are riveted to the rings at assembly so that the rollers and cage form an integral, non-separable unit. Thus, outer or inner races can be omitted if desired, with rollers operating directly on a suitably hardened shaft or housing bore. This cage is an economical design for volume production and possesses excellent operating characteristics for a wide range of applications.



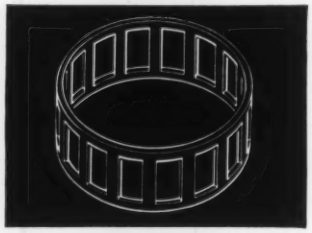
2. POCKETED END RING CAGE

The pocketed end ring cage is restricted to fairly large bore bearings with relatively long rollers. The end rings are bronze. The steel connecting bars are riveted into the end rings and the rollers operate in drilled pockets which guide them accurately. The construction has less tendency to twist or rack, and operates with less end friction because the outside faces of the bronze end rings are smooth uninterrupted surfaces. This type is known as a roller-riding cage, and makes no contact with the bearing races. It can be produced economically in small lots and since it is non-separable, bearing races can be omitted if desired. The characteristics of the pocketed end ring cage make it particularly desirable for applications where long life and heavy-duty service are required.



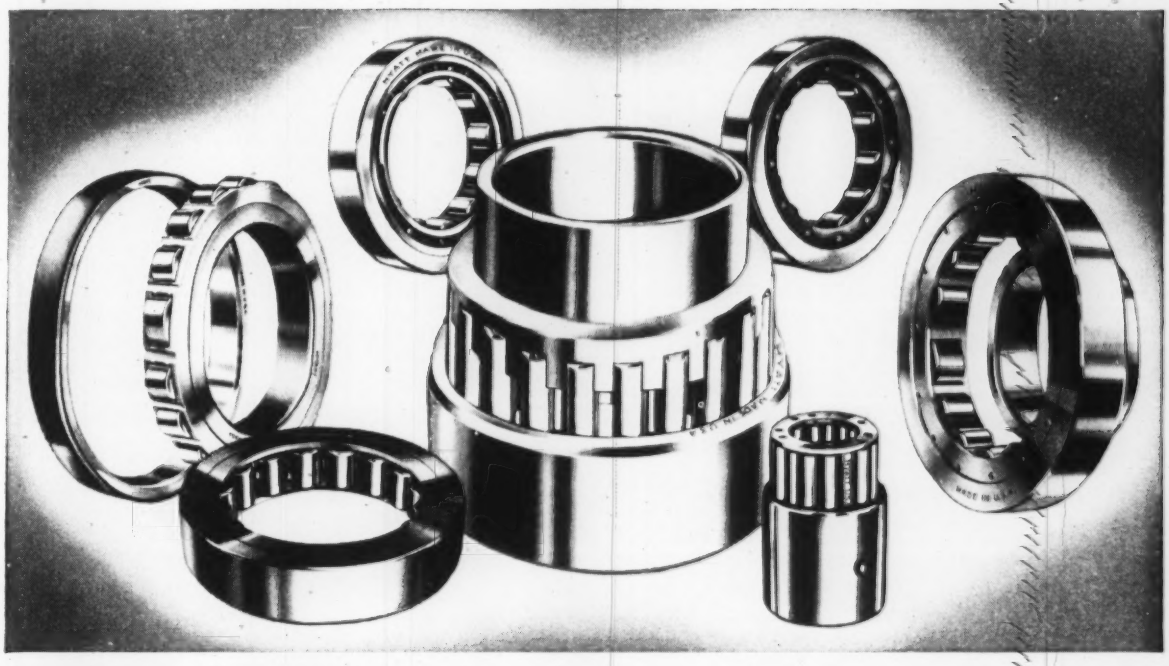
3. STAMPED STEEL SEPARATOR

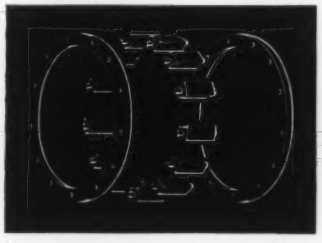
The stamped steel separator does not retain the rollers by itself, but merely separates them. It is a one-piece steel stamping with the separating bars coined to conform to the roller contour, and rides the rollers below their pitch line. Rollers are guided by the race flanges and snap rings, in conjunction with the cage bars. The simple, open design of this separator insures large grease capacity and good lubricant circulation, rendering it relatively insensitive to dirt. Since the separator is retained axially by the roller ends, there is no external requirement for axial location. The stamped steel separator is usable throughout a wide range of bearing sizes where rollers are relatively short (the Hyatt Hy-load series), and is economical for volume production.



4. FORMED BAR CAGE

The formed bar cage is built up of stamped end rings and bars formed to the roller contour. The end rings and bars are riveted together at assembly, making the race and roller assembly a non-separable unit. This cage is used on Hy-load bearings, with double-flanged inner or outer races. This

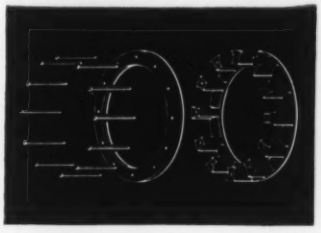




design insures quiet operation, better roller guidance, and provides a smooth contact surface between bars and rollers. This is a roller-riding design requiring no race contact in operation and is well adapted for volume production.

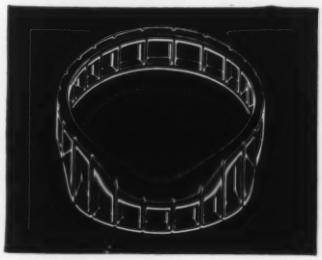
5. DRILLED POCKET CAGE

To construct this type, a bronze cylinder is drilled and reamed to form pockets in which the rollers operate. After the rollers are inserted, a flat end ring is riveted in place so that the rollers are permanently retained in the cage. This design provides extremely close control of the rollers in operation and prevents skewing which would impair both the thrust and radial capacity of the bearing. This is another roller-riding cage comprising a non-separable unit suitable for operation with inner or outer races omitted. The design insures superior performance and is used in applications requiring bearings of better than commercial quality.



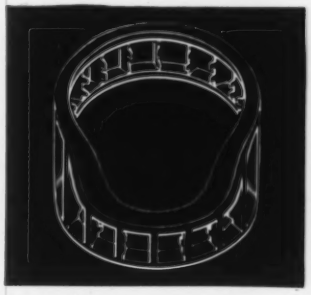
6. SEPARABLE BROACHED POCKET CAGE

This type is used only on the finest-quality bearings where performance is more important than price. It is made of one integral bronze cylinder, with pockets broached for maximum uniformity. This is the preferred type for the finest high-speed precision bearings because it insures minimum friction between rollers and separator, and allows better oil circulation for cooling at high speeds. Moreover, there are no thermal differences in this monolithic construction; the entire unit heats and cools uniformly. The separable feature offers the further advantage of roller removal for inspection of the race operating surfaces.



7. NON-SEPARABLE BROACHED POCKET CAGE

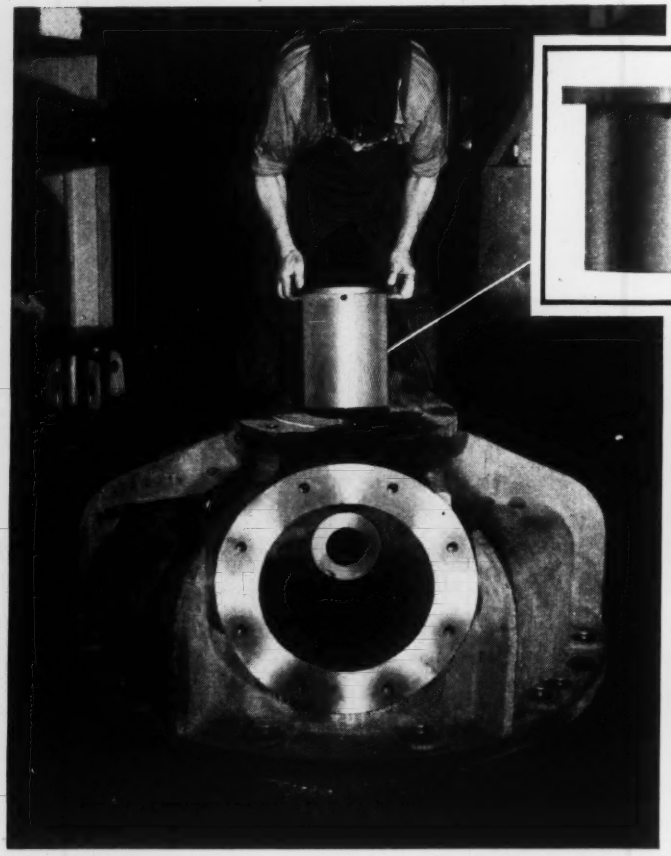
Similar in construction to the above, this design offers all the same inherent operating advantages. It is used in bearings where installation must be "blind," requiring rollers to be retained with the inner or outer race. Controlled roller drop is provided by deforming the connecting bars at assembly after the rollers are in place in the cage. This insures proper retainment but has the disadvantage that the bearing cannot be taken apart for inspection.

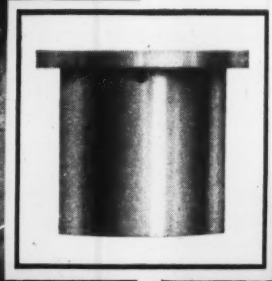


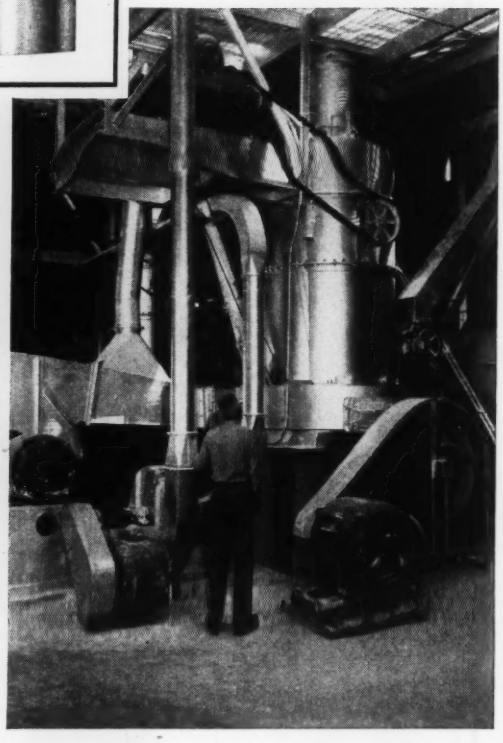
HYATT MANUFACTURES ALL SEVEN TYPES of cylindrical roller bearing retainers described above—each the finest of its type. You will find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales engineer will be glad to help you choose the type best suited to your individual design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT
ROLLER BEARINGS







• Big pulverizing mills made by Raymond Division, Combustion Engineering, Inc., depend on Johnson Bronze Bearings for trouble-free performance the world over. At right is a high side roller mill installed in the Kaiser Gypsum Wallboard Plant at Seattle.

Where One Bearing Can Keep Whole Plant From Shutdown

When you're investing up to $85,000 for a pulverizing mill around which you're going to build an entire plant, you expect to get equipment which will give long, trouble-free performance.

One leading company in the field of designing and manufacturing pulverizing mills for use all over the world makes every effort to do just that—build sturdy equipment of the best available materials which won't break down because of the failure of any one part.

Because bearings play such an essential role in the operation of pulverizing mills, the Raymond Division, Combustion Engineering, Inc., has relied for more than 30 years on cast bronze bearings made by the Johnson Bronze Company of New Castle, Pa.

Johnson Bronze bearings rate high with this Chicago manufacturer because they can be depended upon to keep these expensive units on the job day in and day out and because they are made just the way Raymond Division specifies. That means a very low rejection rate and faster production.

Take the big bronze bearings Johnson makes for journals on a pulverizing mill. They are made to a tolerance of .002 of an inch. Because Johnson consistently meets this specification, the time required to fit the bearing is held to a minimum. A few taps with a rawhide mallet usually slips the bearing into its position.

If your product demands uniformity, investigate Johnson Bronze products. You can depend on them for faster production and longer life in use. Skilled engineers are available to help you decide what type of bearing you need to get the best possible results at lowest cost. Johnson Bronze Company, 525 S. Mill Street, New Castle, Pa.

Johnson Bearings

LEDALOYL (powder metallurgy) • ALUMINUM ON STEEL • BRONZE ON STEEL • STEEL AND BABBITT • CAST BRONZE

—ITEM 607—
For More Information Circle Item Number on Yellow Card—page 19

Facing Page—ITEM 608→

if you make a Cutting Edge.. you should know about

SHARON SPECIAL STEELS

Sharon is a prime producer of hot and cold, flat rolled special strip steels in large coils, cut lengths or sheets especially for cutting blade manufacturers.

If you want exactly the right steel for the job, call in the man with steel experience — your Sharon Steel Salesman.

Typical Sharon products used by leading cutlery manufacturers include:

VANADIUM STEELS — particularly adaptable to cutlery manufacture.

STAINLESS — both straight chrome and chrome-nickel.

PLATES —

SPRING STEELS — of every analysis.

N.A.X. and COR-TEN — hi-tensile low-alloy steel.

FORGING INGOTS and BILLETS —

GALVANITE* — a superior hot dip zinc coated steel.

SHARON STEEL CORPORATION

Sharon, Pennsylvania

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SHARONSTEEL

Manufacturers Using Special Steels

Should Have These Booklets:

430 STAINLESS — a complete review of a popular straight chromium grade.

GALVANITE* — The story of one of the most popular hot dip zinc coated steels.

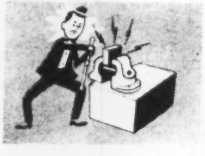
SHARONART* — Rolled-in design steels with excellent illustrations.

*Trademark registered by Sharon Steel Corporation.

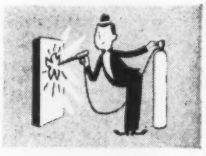
A combination...for relaxation at Home

Laminated plastics... a combination of properties at work

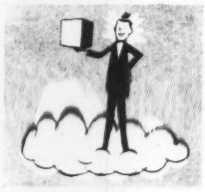
It takes a combination of properties to satisfy many of your basic material requirements. Synthane laminated plastics provide a unique combination of mechanical, electrical and chemical properties plus ease of machining.



COMPRESSIVE STRENGTH



HEAT RESISTANCE



LIGHT WEIGHT

WEAR RESISTANCE

High-speed reversing clutch cone made of Synthane molded-macerated laminated plastic increases productivity of automatic screw machines. Synthane meets all the demands of high-speed clutch operation . . . *light weight, great strength* and *excellent heat resistance* for split-second reversing of a positive spindle drive operating as high as 3025 rpm and with operating temperature of cone going up to 250°F. This Synthane clutch cone provides smooth, positive clutch action, is long wearing, and is not distorted or deteriorated by the high heat.

Property combinations! Synthane has them... in over 30 individual grades... sheets, rods, tubes, moldings and completely fabricated parts. Send for free illustrated catalog today.

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

—ITEM 609—

For More Information Circle Item Number on Yellow Card—page 19

MACHINE DESIGN
May 31, 1956

No Stress, No Strain

YOU CAN'T PLOT a stress-strain curve for an engineer. Nor can you determine his fatigue characteristics from an *S-N* diagram.

Such tests are essential for engineering materials. No one would attempt to evaluate a material without them. Yet important decisions on men are made every day without any systematic evaluation technique.

In most engineering departments, management cannot maintain close personal contact with each and every engineer. Management thus has trouble acquiring the detailed personal knowledge necessary for an intelligent evaluation.

To compensate for this loss of personal contact, there are methods to provide adequate knowledge of an engineer and his performance, just as properties and service tests provide information on materials. The names are different — merit evaluation, performance testing, etc. But the purposes are the same—to provide a sensible basis for evaluation against a consistent, unbiased scale.

A merit evaluation system, if intelligently selected and properly administered, can help provide the bridge between the engineer and his management. Like materials tests, merit evaluation programs do not supplant personal judgment. But they can supplement it — very effectively.

People cannot be selected, specified and applied with the same cold logic as engineering materials. The human touch is needed. But if well handled, a merit evaluation program can reduce the unit loading on both the engineer and his management to a tolerable level — practically no stress and no strain.

Robert L. Stedfeld

ASSOCIATE MANAGING EDITOR

Any method for merit evaluation of design-section personnel must have several attributes. It must be fair. It must be comprehensive enough to give a clear picture of the skill, degree of job enthusiasm, and experience of each engineer and draftsman. Yet it must accomplish these objectives without excessive paperwork.

The system described in this article was originally developed and proved for one type of engineering operation. But its basic features apply to almost any design group. Its chief virtues—simplicity, directness, and only the necessary record keeping—are excellent goals for any method of evaluating engineers.

Here's a simple straightforward Merit Evaluation

By Harold Blye*
Bellerose, Long Island, N. Y.

METHODS of evaluating engineers and keeping personnel records vary highly from one engineering department to another. Here is one evaluation program—a system proved particularly effective for certain types of design groups.

It is not a panacea. But it has the definite advantages of simplicity, relatively little paperwork, and the ability to furnish both a broad-perspective and a detailed view of engineering-group personnel. The system is believed to have many features of definite value for almost any size engineering group.

Objectives of the System: The merit-evaluation system provides records on, and "machinery" for obtaining, several kinds of evaluation information about each engineer and draftsman in the department. Built into it are:

1. A merit evaluation at regular intervals.
2. A method of comparing the merit evaluation against a job-classification and pay scale.
3. A record of specialized experience, education, and skills.
4. Summary and individual progress records.

*Formerly Engineering Division, American Machine and Foundry Co., New York 16, N. Y.

The original design group for which the evaluation system was set up was a rapidly expanding one; it grew from 20 to 130 engineering and drafting employees in ten months. This "shock load" was handled smoothly.

In this expanding group, new personnel were added almost daily. Personal evaluation of individual employees by top engineering-department management was impossible. Therefore, the merit evaluation program had to be considered, on its own merits, convincingly "fair" by every individual within the section. To the best knowledge of everyone involved, this objective was also achieved.

Again because of the rapid expansion, the system had to keep close track of the experience, skills, training and education of each individual. So a method of obtaining this information and keeping it current was included. This method, by the way, could be helpful where project changes require shifts in assignment. It also helps in determining the overall skills and capabilities of the design group, as a guide to future planning.

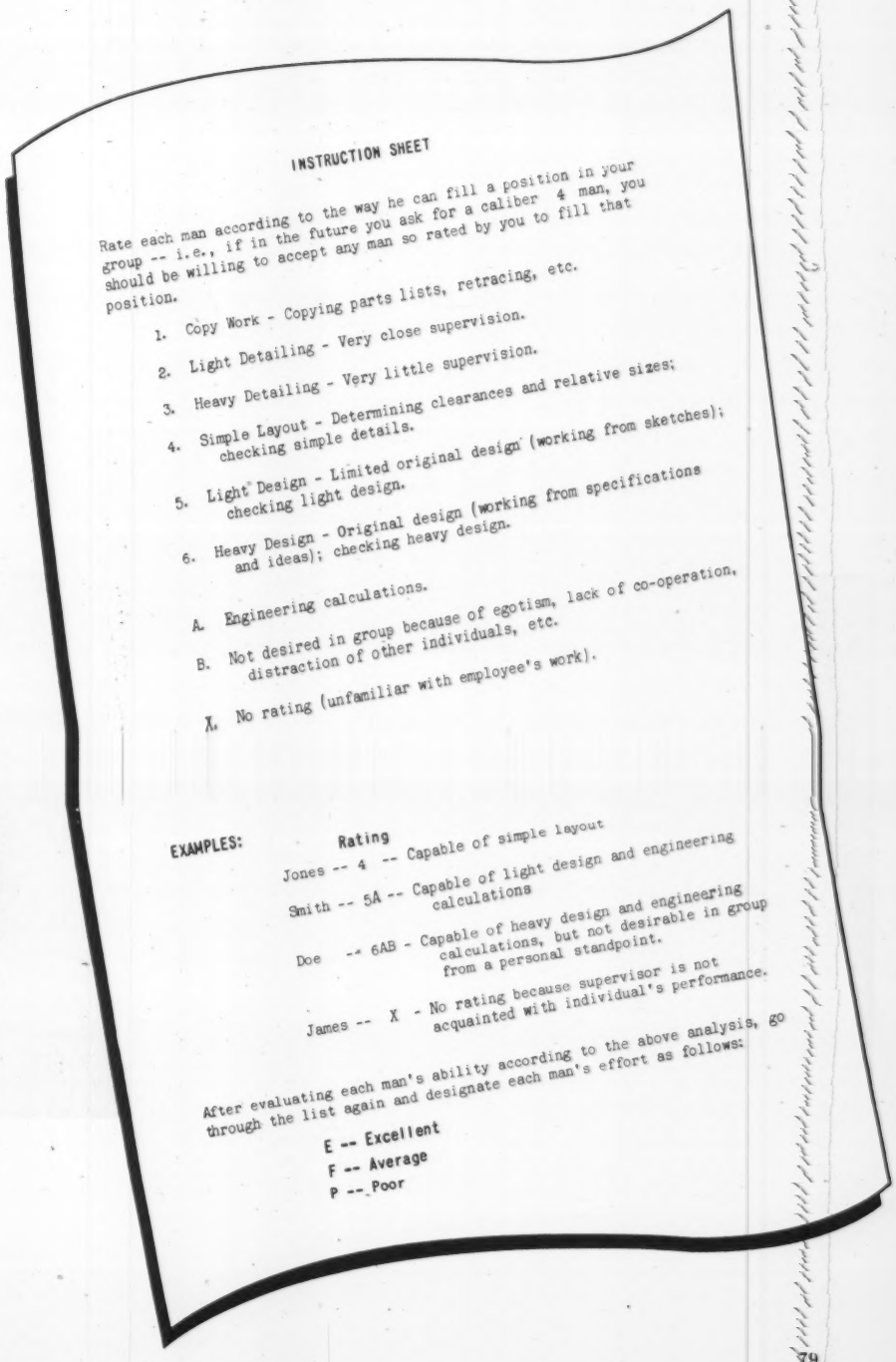
Merit Evaluation System: Below the supervisory level, three general job categories are used for reference purposes: draftsmen, senior draftsmen, and designers, Table 1. Each of these reference classifications is broken down into skill classifications, which are numbered. A further subdivision of each of these skills into "group ratings" permits a direct relation of each group rating to a maximum salary.

In Table 1, salary figures are shown as percentages of the top salary in the design section. In actual practice, a salary range would be established for each skill group. A maximum salary within this range would be established for each group rating.

The group rating numbers are used as a basis

System . . . a method for

- Classifying design-engineering jobs
- Rating skills and attitudes
- Recording experience and training
- Summarizing individual progress



INSTRUCTION SHEET

Rate each man according to the way he can fill a position in your group -- i.e., if in the future you ask for a caliber 4 man, you should be willing to accept any man so rated by you to fill that position.

1. Copy Work - Copying parts lists, retracing, etc.
2. Light Detailing - Very close supervision.
3. Heavy Detailing - Very little supervision.
4. Simple Layout - Determining clearances and relative sizes; checking simple details.
5. Light Design - Limited original design (working from sketches); checking light design.
6. Heavy Design - Original design (working from specifications and ideas); checking heavy design.

A. Engineering calculations.

B. Not desired in group because of egotism, lack of co-operation, distraction of other individuals, etc.

X. No rating (unfamiliar with employee's work).

EXAMPLES: Rating

Jones -- 4 -- Capable of simple layout

Smith -- 5A -- Capable of light design and engineering calculations

Doe -- 6AB - Capable of heavy design and engineering calculations, but not desirable in group from a personal standpoint.

James -- X - No rating because supervisor is not acquainted with individual's performance.

After evaluating each man's ability according to the above analysis, go through the list again and designate each man's effort as follows:

E -- Excellent
F -- Average
P -- Poor

Fig. 1 — Instruction sheet for merit rating is given to supervisors at a closed quarterly meeting as a guide for rating each engineer and draftsman.

SUPERVISOR'S RATING BLANK

Rated by: Rogers

Date: 3/1/56

Name	Rating
Abel	6.0AE
Baker	2.5E
Charlier	3.0E
Dugan	X
Everest	5.0F
Frost	6.0E
George	5.5E
Hillman	6.0E

Fig. 2 — Above — An individual rating blank is filled in by each supervisor with his own rating for each man.

SUPERVISORY EVALUATION AVERAGES

Date: 3/1/56

Name	Average Rating	Lombardo	Masters	Nelson	Otto	Palmer	Rogers	Spotts	Turner	Underwood	Victor	Wolf
Abel	6.00AE	6AE	X	X	6AE	X	6AE	X	6AE	6AE	6AE	X
Baker	3.25E	2.5E	X	X	6AE	X	2.5E	2F	X	X	X	X
Charlier	4.00E	4E	X	X	4E	X	3E	4F	4E	5E	4E	X
Dugan	2.25F	2E	X	X	X	2.5F	X	X	X	X	X	X
Everest	5.10F	4.5F	X	6E	5F	X	5F	X	X	5F	X	X
Frost	6.00AE	6AE	X	X	6AE	X	6AE	6F	6E	6E	6E	X
George	5.00AE	4.5E	5AE	X	X	X	5.5E	X	X	X	X	X
Hillman	5.83AE	5E	6AE	X	6E	X	6E	X	6E	X	6E	X

The whole merit-evaluation rating for any individual thus consists of two basic elements: (1) a numerical skill index, and (2) a letter designation indicating degree of effort, and possibly other traits and abilities. A typical evaluation rating might be "5AF," indicating someone capable of light design and engineering computations, who put an average amount of effort into his job.

How the Evaluation System Works: The mechanics of getting a rating and maintaining records are not complicated.

Fig. 3—Below—Supervisors' ratings are collected and noted on a summary form. Ratings are then averaged, and questionable points resolved by personal consultation.

for merit evaluation of each designer or draftsman. However, this evaluation does not tell the whole story. It is generally recognized that a person of exceptional skill may still be an undesirable employee because of poor effort or other personal traits. A simple letter code is used along with the group rating numbers to indicate these characteristics:

E. Excellent effort.
F. Average effort.
P. Poor effort.
B. Not desirable in a group because of personal failings.

Other features can also be built into the rating with a letter code. For instance, an "additional skill index" can be used to indicate engineering capabilities not covered by the standard group rating classification. The only additional rating found necessary in the group for which the system was organized was one indicating a capability for engineering computations. This was designated by an A attached to the merit evaluation rating.

Table 1—Job Classifications

Reference Classification	General Group	Skill	Group Rating	Maximum Salary (% of highest)
Draftsman	1	Copy Work	1.00	37.5
			1.25	40.5
			1.50	43.8
			1.75	46.8
	2	Light Detailing	2.00	50.0
			2.25	53.0
			2.50	56.2
			2.75	59.2
Senior Draftsman	3	Heavy Detailing	3.00	62.5
			3.25	65.5
			3.50	68.8
			3.75	71.8
	4	Simple Layout	4.00	75.0
			4.25	78.0
			4.50	81.2
			4.75	84.2
Designer	5	Light Design	5.00	87.5
			5.25	90.5
	6	Heavy Design	5.50	93.8
			5.75	96.8
			6.00	100.0

MASTER EVALUATION FORM

Summary of Periodic Evaluations

Clock No.	Employee	Job Category	6/1/55	9/1/55	1/1/56	3/1/56	Composite Average	Rating Max Salary	Actual Hourly Rate	Evaluation Ratio
1002	Abel	Designer	6.00AE	6.00AE	6.00AE	6.00AE	6.00AE	100.0	97.5	1.02
8600	Baker	Drftsmn.	2.66E	3.00E	2.16E	3.25E	2.75E	59.2	50.5	1.15
8634	Charlier	Drftsmn.	3.50E	3.75E	3.80E	4.00E	4.00E	75.0		
8935	Dugan	Jr. Drft.	2.00F	2.00F		2.25F				
8722	Everest	Des. Chkr.	5.20AF							
1008	Frost	Designer	6.00AE	5.00F	5.00F	5.10F	2.00F	50.0	31.5	1.17
				6.00AE	5.64AE	6.00AE	5.00F	87.5	100.0	1.57
							6.00AE	100.0	100.0	0.87
										1.00

Fig. 4 — Above — Master evaluation form lists "historical" rating information for each man, plus comparative salary information. Figures in *Rating Max Salary* and *Actual Hourly Rate* columns are percentages in this example (see Table 1); in actual practice, these would be dollar-per-hour figures.

Interpretation of Fig. 4

Abel: Grant only limited increase; start thinking about future possibilities.
Baker: Performance satisfactory; grant increase when eligible.
Dugan: Skill outstanding; reclassify immediately with increase.
Everest: Performance not consistent with present salary; consider release.
Frost: Top salary reached; consider for supervisory job or transfer to wider-scope activities.

SKILL ANALYSIS

Date: 10/1/55

Employee	General Machinery	Automatic Machinery	Tools and Dies	Electro-Mech. Equipt.	Electronic Equipment	Servo-mechanisms	Hydraulic Equipment	Structural Equipment	Ventilating Equipment	Airframe Type Design	Perspective Drawing	LeRoy Ink Tracing
SUPERVISORS												
Masters	X	X	X				X					
Nelson	X	X	X									
Turner	X	X										
Williams				X	X							
Palmer		X										
Otto	X	X		X			X					
DESIGNERS												
Abel	X					X		X				
Everest	X		X						X			
Frost	X	X	X			X						
Hillman	X	X										

Fig. 5—Right—Skill analysis records areas of design experience to supplement the merit evaluation and help in overall planning.

Every three months, the chief designer calls a closed meeting of all design supervisors for the purpose of establishing ratings for each member of the design group.

There are several reasons for holding this meeting regularly. For one thing, it requires each supervisor to consider the current status of each man in the design section; this helps to point up the need for additional personnel, or to spot inefficiencies, before the situation gets serious. At the same time, a regular meeting helps reassure design-section employees that they're not "forgotten men"—either job-wise or pay-wise.

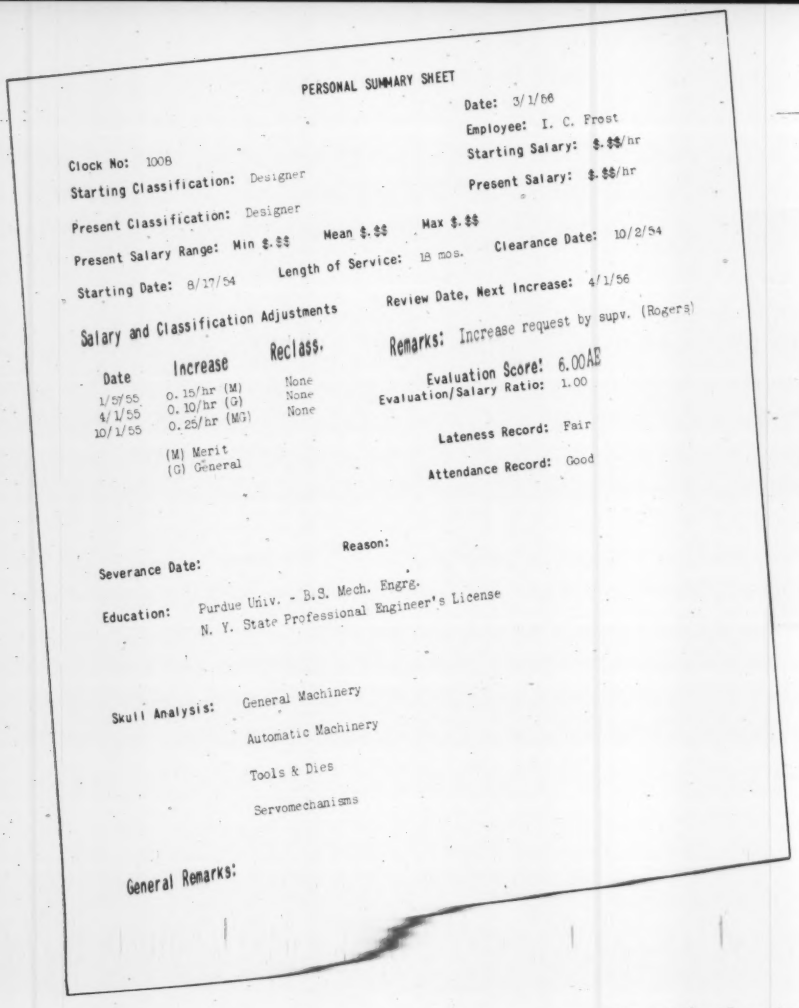
At the meeting, each supervisor is given an instruction sheet, Fig. 1, which briefly outlines all factors entering into the merit-evaluation analysis. He is also given entry blanks, Fig. 2, that list the entire engineering and drafting personnel of the design section in alphabetical order. These also provide space for the evaluation posting.

Evaluations are arrived at independently by each supervisor, without any group consultation. Supervisors are *not* informed of the salary range corresponding to each skill or "group rating" in Table 1.

A supervisor only evaluates those men on the entire listing whose performance he knows well enough to make the evaluation honest and significant. If he has no knowledge of the individual's ability, he places an X opposite the name.

The chief designer subsequently tabulates the individual supervisor's evaluations and tabulates them, Fig. 3. He then arrives at an average rating for each design-section employee, resolving any large or unusual differences in ratings by consultation with the supervisors involved.

These average evaluations are then transcribed onto a master evaluation form, Fig. 4. This form is the current guide, since it gives not only the composite average, based on many readings, but



PERSONAL SUMMARY SHEET

Date: 3/1/56
Employee: I. C. Frost
Clock No: 1008
Starting Salary: $.$$/hr
Starting Classification: Designer
Present Salary: $.$$/hr
Present Classification: Designer
Present Salary Range: Min $.$$ Mean $.$$ Max $.$$
Starting Date: 8/17/54 Length of Service: 18 mos. Clearance Date: 10/2/54
Review Date, Next Increase: 4/1/56

Salary and Classification Adjustments

Date	Increase	Reclass.
1/55	0.15/hr (M)	None
4/1/55	0.10/hr (G)	None
10/1/55	0.25/hr (MG)	None

(M) Merit
(G) General

Remarks: Increase request by supv. (Rogers)
Evaluation Score: 6.00AB
Evaluation/Salary Ratio: 1.00
Lateness Record: Fair
Attendance Record: Good

Severance Date: Reason:

Education: Purdue Univ. - B.S. Mech. Engrg.
N. Y. State Professional Engineer's License

Skill Analysis: General Machinery
Automatic Machinery
Tools & Dies
Servomechanisms

General Remarks:

Fig. 6—Personal summary record lists pertinent information on each design-section employee. This confidential form is up-dated regularly and is used as one of the bases for considering increases or reclassification.

also shows progressive trends, for better or worse.

Several very significant facts can be picked from the master evaluation form. The *Composite Average* column in Fig. 4 represents an average of the four periodic ratings. It is the current evaluation of an individual. In the next column, the maximum salary corresponding to this composite average is listed, obtained in this case from Table 1. The employee's actual hourly rate is noted in the suceeding column.

A comparison of these two columns indicates clearly whether a man's performance is consistent with his present salary. This comparison is given in terms of an "evaluation ratio," shown in the last column of Fig. 4. The evaluation ratio is the ratio between a man's "maximum rating salary" and his actual hourly rate.

Obviously, an evaluation ratio of 1.00 indicates average performance. A ratio below 1.00 indicates performance not consistent with present salary. Above 1.00 indicates performance above average; the individual should be considered for an increase when he becomes eligible. A ratio too far above 1.00 may indicate that the person involved is not classified properly, just as a ratio too far under 1.00 may indicate the necessity for termination of employment.

The Skull Analysis: As an adjunct to the merit-evaluation system, a record of specialized experience is also helpful. This record became known by the somewhat grisly term, *skull analysis.*

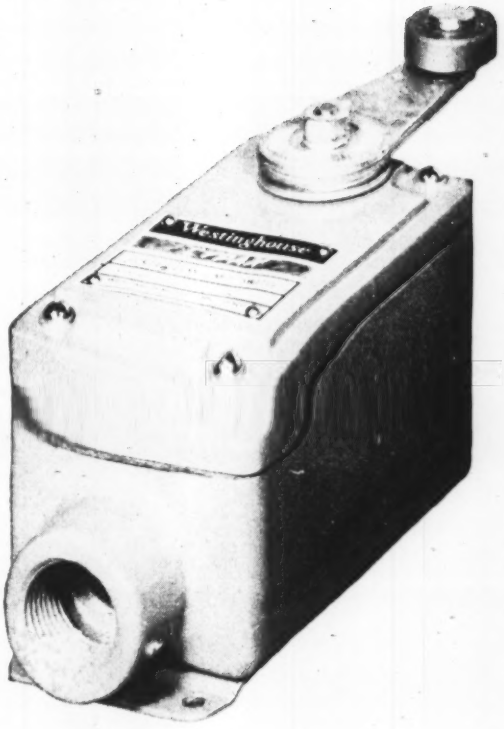
Originally, the skull analysis was needed to plan new work of rather unusual character which was assigned to the design section, and to determine whether the requisite skills were available. Later, it proved helpful in fulfilling requests by other sections for the loan or permanent placement of people with certain specialized experience.

For this purpose, a chart, Fig. 5, is prepared listing this specialized experience. The particular experience categories shown in Fig. 5 were based on those found to be significant in the design section and in new work. They would be different, of course, for other design sections. Only two years or more of experience in the specialized field is counted.

Information for the skull analysis record is maintained by requesting an up-dating of the information at periodic intervals. The information requested also includes specific machines or products worked on, and actual number of years of experience on each. At the same time that skull analysis information is requested, information on any scholastic or educational achievements can also be obtained.

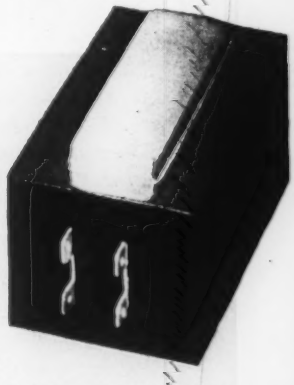
Individual Summary Record: All of the previous information on every individual, plus information from the personnel department, is collected on a *Personal Summary Sheet,* Fig. 6. These records, in bound form, are referred to only by the chief designer or top management, since they represent data of a highly confidential nature. The Personal Summary Sheet is used to help evaluate an individual's eligibility for an increase and/or reclassification.

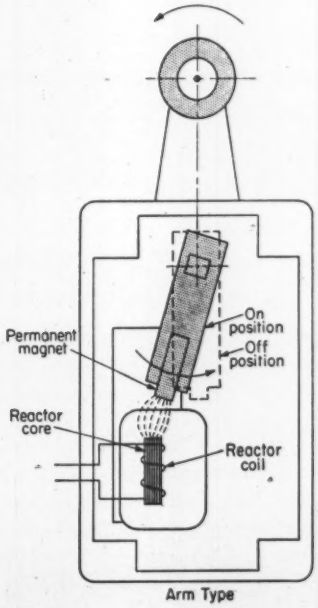
scanning the field for Ideas



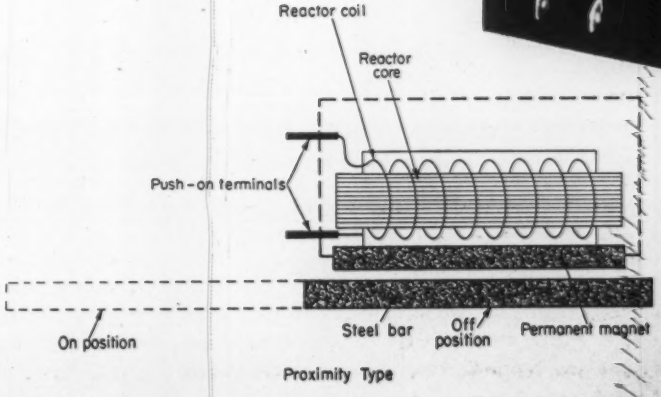
CONTACTLESS SWITCH designs eliminate problem of contact erosion and pitting, permit operation in inflammable or explosive atmospheres, and offer extremely long life expectancies. Developed by Westinghouse Electric Corp. for use with Cypak electrical logic elements, the switches are made in two basic constructions—a lever-arm type and a proximity type. In both designs an encapsulated coil of wire wound around a reactor core serves as the electrical on-off element. Electrical impedance to current flow through the coil varies inversely with degree of saturation of the core.

In the lever-arm design, the core is saturated and the switch is "on" when a permanent magnet is positioned near the reactor. The magnetic field flux saturates the core. In the proximity switch, a fixed-position permanent magnet is also employed to saturate the reactor core, permitting current flow. However, when a steel bar is moved in parallel to the magnet, the magnet flux is shunted away from the coil assembly and the switch is turned "off."

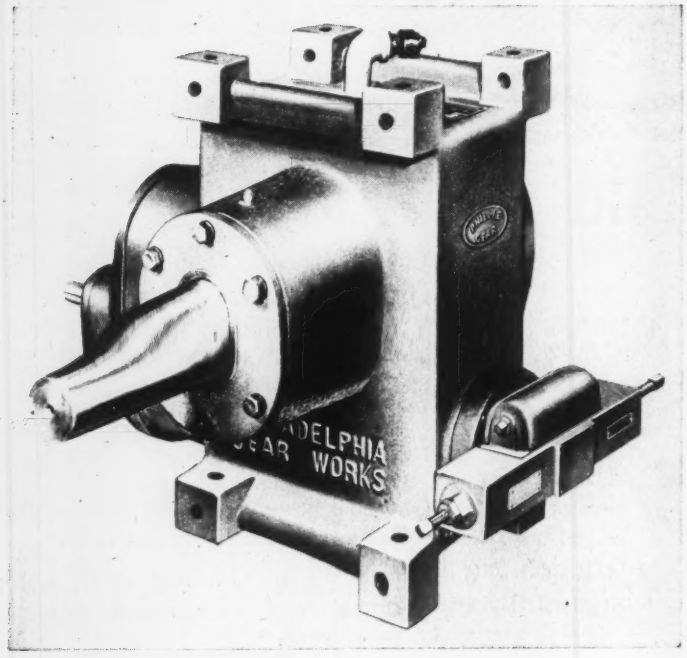




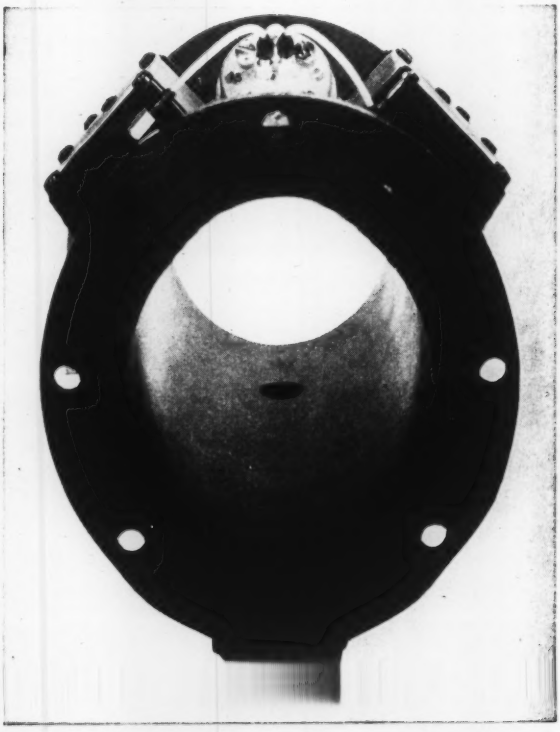
Arm Type



Proximity Type

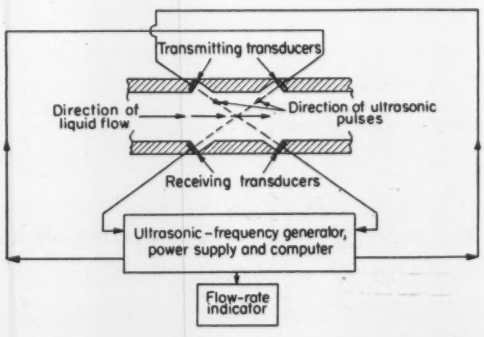


MULTIPLE MOUNTING SUPPORTS on cast frame members facilitate their design and installation flexibility. Employed in the design of change-gear speed reducers manufactured by the Philadelphia Gear Works Inc., the construction feature permits mounting from any of four sides.



ACCURATE FLOW MEASUREMENTS of a wide variety of fluids can be accomplished by an ultrasonic flowmeter that has no moving parts. Developed by W. L. Maxson Corp., the instrument uses controlled electro-acoustic impulses for rate-of-flow measurements and features a smooth-bore construction that produces negligible pressure drop. Also, flow in either direction can be measured without reversal of the metering section.

Basically, the unit consists of a metering section on which are mounted piesoelectric crystals and associated circuits employed to generate and detect ultrasonic impulses. Energy pulses of the same frequency are propagated at an angle across the stream from transmitting crystals toward receiving crystals. Because of the effect on transit time by the moving liquid, the downstream receiving transducer detects a higher repetition rate of pulses than that transmitted and the upstream receiving transducer a lower rate. The difference in repetition rates is directly proportional to fluid velocity or volumetric flow rate.

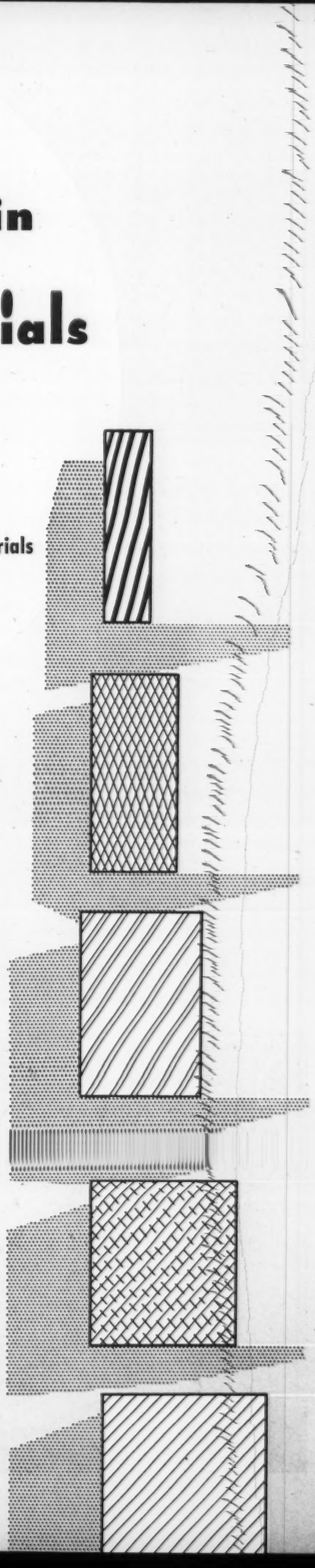


Today's Trends in

Engineering Materials

an up-to-date progress report for designers on

- Current materials selection practices
- Creative design opportunities with new materials
- Future materials developments



Materials are the cornerstones on which the design of a new product is built. By raising a service limit, or by offering improved characteristics, a different material may open up a whole new area of design progress.

In this fast-moving age, new developments in materials crop up daily. Keeping posted on these individual developments is a major task for a designer—but a necessary one.

To make this job easier ten specialists on materials have prepared the following authoritative reports. Each article summarizes an area of critical interest in design. New materials are reviewed, long-term trends are pointed out, and opportunities for creative design with materials are discussed. Together, these reports present a comprehensive picture of today's—and tomorrow's—materials in design.

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Sleeve Bearing Materials 108
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New applications, new compositions, and new production methods highlight the expanded use of

By P. D. Frost
Chief, Light Metals Div.
Battelle Memorial Institute
Columbus, Ohio

IN RECENT years, the three lightest structural metals—aluminum, magnesium and titanium—have inspired sweeping changes in the design of structures of almost every type.

Aluminum Alloys

First associated with pots and pans, aluminum has for many years been the principal material of aircraft construction. However, this versatile metal is now moving rapidly into structural fields formerly dominated by steel, copper, wood and stone. New applications for aluminum have been found in building construction, surface transportation on both land and sea, and electric conductors. Aluminum curtain-wall construction has proved to be highly satisfactory in the Alcoa building in Pittsburgh, and has since been used for many other large buildings. Aluminum alloys are also being used for bridge construction and for large crane jibs, two applications formerly reserved only for steel.

Several new aluminum alloys have recently been developed to the commercial stage or are just emerging from the laboratory. X7178 and 7001 are high-strength sheet and extrusion alloys of the Al-Mg-

Fig. 1—Tail cones for the B-47 jet bomber, fabricated from AZ31 magnesium alloy sheet

LIGHT ALLOYS

- Aluminum
- Magnesium
- Titanium

Zn-Cu type. Like 7075, these alloys will be useful at room temperature but lose strength rapidly at temperatures above 250 F. X7079 is a new high-strength forging alloy for use at normal temperatures. XA140-F is an experimental casting alloy and X2219 a new wrought alloy, both for use at elevated temperature. Some tensile properties of these materials are given in Table 1.

Magnesium

While aluminum is seeking other worlds to conquer, magnesium is continuing to establish its place with aluminum in the aircraft industry. Substantial quantities of magnesium sheet were used in the B-36 intercontinental bomber. More recently, the B-47 jet bomber has utilized magnesium in a number of structural components. An important application is the tail cone, Fig. 1.

The first all-magnesium military aircraft, an F-80C jet fighter, was completed and flown in June, 1955. Built by East Coast Aeronautics Inc., this modified aircraft is an example of thick-skin (0.064 to 0.375-in.) monocoque design. This type of construction eliminates a great many structural parts, such as stiffeners and fasteners, and allows more space for fuel. The simplified construction also effects an estimated 20 per cent saving in cost of production. In the wing alone, the number of structural parts was reduced from 1649 to 508, and the number of fasteners from 42,700 to 16,000. The flight experience that will be obtained with this airplane should influence greatly the future of

Fig. 2—Innerbody assembly of a supersonic ram-jet engine capable of performing at 600 F or higher. The rolled and welded skin is HK31-T6 magnesium alloy

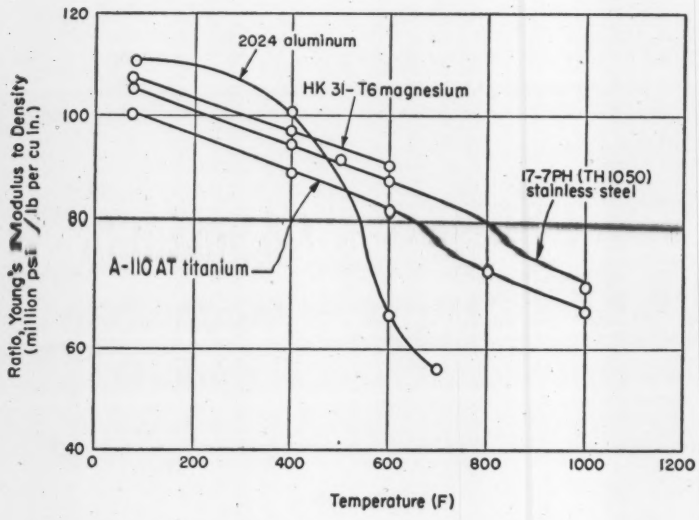
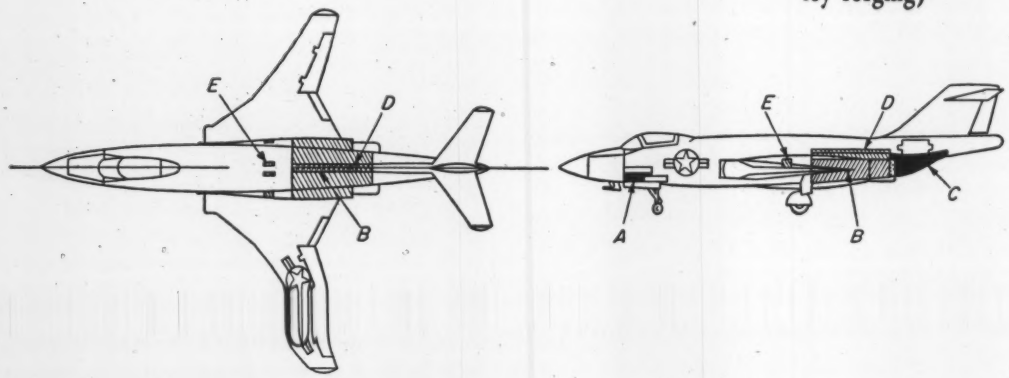


Fig. 3 — Left — Ratio of Young's modulus to density for several structural alloys over a range of temperatures

Fig. 4 — Below — Places where titanium has been used in military aircraft: *A*, forward fuselage panels (commercially pure sheet); *B*, keel assembly (8 Mn alloy sheet); *C*, fairing assemblies (commercially pure sheet); *D*, floor assembly (8 Mn alloy sheet); and *E*, engine-mount trunnions (alloy forging)



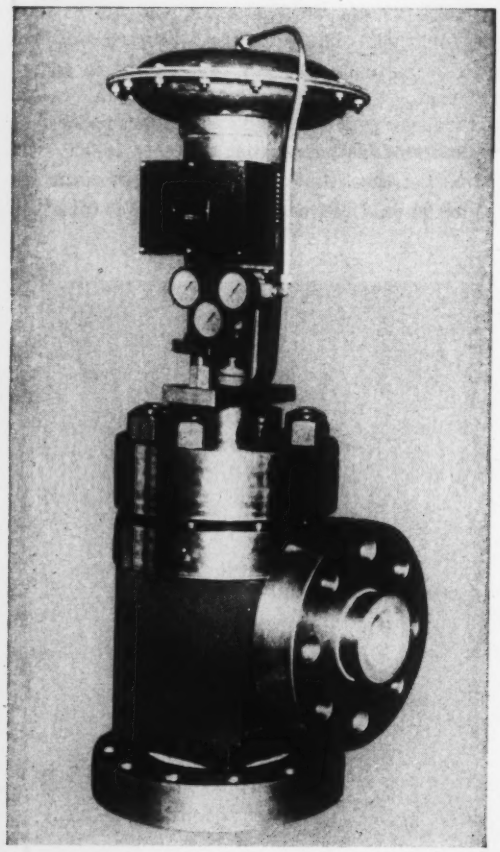


Fig. 5—Left—Valve body made of 320-lb titanium forging for service in a corrosive environment

magnesium in aircraft.

Newer magnesium alloys are playing an important part in aircraft structures, many of which are subjected to high temperatures. Tensile properties of several newer alloys are given in Table 2.

Perhaps the alloy of greatest promise at this time is HK31, a magnesium-zirconium-thorium composition, which recently became available as sheet. An illustration of an elevated temperature application for this material is shown in Fig. 2. Marquardt Aircraft Co. has made extensive tests on HK31-T6 sheet and castings for use in ramjet engines. At temperatures above about 500 F, HK31-T6 has a higher ratio of strength to weight than commercial aluminum alloys.

Although its strength is not so high as that of stainless steel, HK31 can compete with stainless and titanium where stiffness is a consideration. Stiffness in sheet is a function of the modulus of elasticity and thickness of the sheet material. Light-weight alloys can be used in thicker sheet sections without a weight penalty, thus providing stiffness. On the other hand, even the high-

strength steels heat treated to well over 200,000 psi are not always satisfactory in certain sheet applications, such as aircraft skin, because their weight requires that they be used as thin sheet which does not provide adequate stiffness. The relationship of Young's modulus of elasticity to density is shown for several materials at different temperatures in Fig. 3. Note that HK31-T6 alloy is superior to 2024 aluminum alloy, 17-7PH stainless steel, and A110AT titanium alloy at 450 to 600 F.*

Magnesium is being used for many other military applications in addition to aircraft. Radar equipment and electronic components are only two of a long list of such applications. Military products accounted for the larger part of magnesium consumption for many years. This has changed over the years since World War II, and numerous new peacetime uses for magnesium have developed.

Titanium

The third important light structural metal is titanium. The use of titanium has been, and will continue for several years to be restricted almost exclusively to military aircraft. This is only because the high cost of titanium mill products prevents them from being used for other military and civilian applications.

Production of titanium sponge (about 7200 tons in 1955) is ahead of the demand for mill products.

*A. V. Levy—"Use of HK31 Magnesium-Thorium Alloy for Ramjet Engine Construction," 11th Annual Convention, Magnesium Association, October 31-November 1, 1955.

Table 1—Tensile Properties of New Aluminum Alloys[1]

Alloy	Temperature (F)	Ultimate Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)	Applications
X7178	Room	84	73	5	Extrusions, plate, sheet
7001	Room	99	93	10	Extrusions, plate, sheet
X7079	Room	77	67	13	Forgings
XA140-F	Room[2]	34	29	1	Castings
	600[2]	20	14	25	Castings
X2219	Room	62	43	16	Extrusions, forgings
	600	20	15	25	Extrusions, forgings

[1]Properties are representative but not necessarily typical. Solution-treated and artificially aged condition unless otherwise noted.
[2]As-cast condition.

Table 2—Tensile Properties of New Magnesium Alloys*

Alloy	Temperature (F)	Ultimate Strength (1000 psi)	Yield Strength (1000 psi)	Elongation in 2 in. (per cent)	Applications
HK31	Room	37	21	14	Extrusion, plate, sheet
	600	18	11	22	Extrusion, plate, sheet
HK31	Room	31	16	6	Castings
	600	20	12	22	Castings
EK30A	Room	23	16	3	Castings
	600	12	8	70	Castings
HZ32	Room	29	15	6	Castings
	600	12	8	38	Castings

*All properties cited for the solution treated and artificially aged condition. Properties are not necessarily typical.

Emphasis was placed by the government in 1955 on the improvement of titanium technology to increase the tonnage of mill products consumed. Many problems remain to be solved; nevertheless, producers and manufacturers are rapidly becoming educated in the fabrication of titanium and titanium alloys. Examples of applications for fabricated parts made from titanium are shown in Figs. 4 and 5.

Recently developed heat treatments have opened new horizons for the application of the alloys in highly stressed structures. Fig. 6 shows, for example, that 6Al-4V titanium alloy heat treated to 180,000 psi ultimate tensile strength has a superior strength to weight ratio than common aluminum structural alloys or steels.

Titanium alloys are, at present, being used at lower strength levels. Thus, the 8 Mn titanium sheet alloy is always used in the annealed condition because it must be formed, and problems associated with heat treating formed parts have not been overcome. An immediate objective of the titanium industry and the government is to learn how to form sheet alloys in the solution-treated condition, avoiding distortion by age-hardening the formed parts at intermediate temperatures. Alloys and heat treatments amenable to this practice are expected to be available in the next year or two.

FIGURE CREDITS

Brooks & Perkins Inc. ..... Fig. 1
Marquardt Aircraft Co. ..... Fig. 2
Rem-Cru Titanium Corp. ..... Figs. 4 and 5

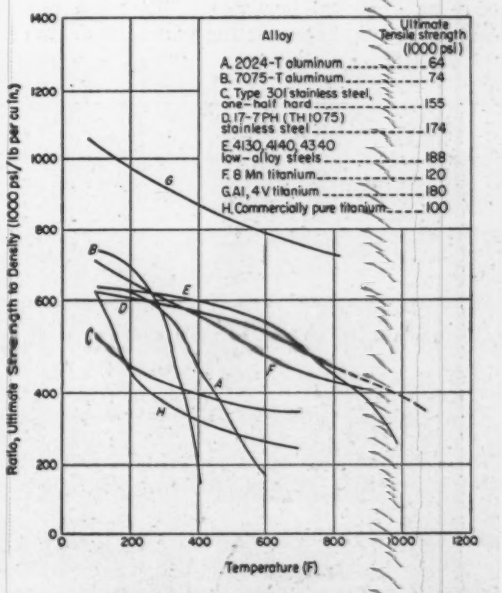


Fig. 6—Strength-weight comparison of several aircraft materials on the basis of ultimate tensile strength divided by density

ELECTRICAL INSULATING

. . . a survey of today's design and selection practices for solid dielectrics – phenolic, polyester and epoxy plastics, silicones, and mica.

THE IMPORTANCE and engineering significance of electrical insulating materials and systems are today widely recognized. Insulation is now one of the four basic design components of electrical equipment and machinery. It has taken a place of equal importance with the magnetic or electrical circuit elements, the electrical conductors, and the mechanical supporting structure. And the chemical industry has matched this viewpoint by producing many new materials which are good electrical insulation when used alone or in combination with other materials.

Present Insulating Materials

A number of chemical resin families are used today as electrical insulation. They are used as bonding agents, impregnating varnishes or, in combination with fillers and catalyst, for molding or encapsulating windings or component parts of electrical apparatus. Some of these materials are capable of being extruded into tubes and rods; some can be made into synthetic fiber, which can be woven into cloth and tapes; some can be formed into film sheet material which may be slit into tape or combined with other materials and used as either wrappers or tape.

The four families of resins most widely used are: (1) phenolic, (2) polyester, and (3) epoxy, all of which are organic, and (4) silicone, which is inorganic. Melamine resins, fluorocarbons, isocyanides, vinyls, polyethylene, and many others, are used as electrical insulating materials in special applications where the particular properties of the materials make them especially suitable.

Basic Forms: The materials most generally used

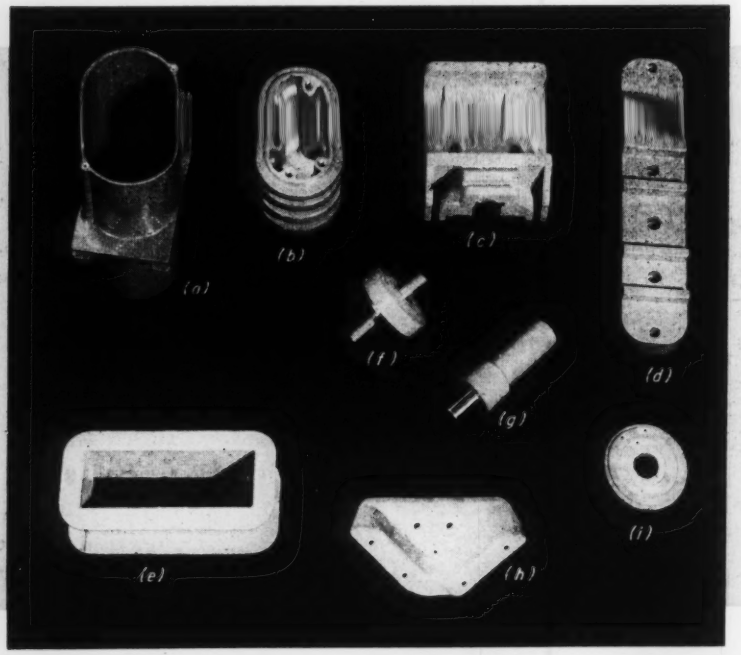


Fig. 1 — Molded glass-fiber reinforced polyester plastic parts: *a*, circuit-breaker booster cylinder; *b*, standoff insulator for crane-rail support; *c*, contact support for a 5 kv switch; *d*, bus support; *e*, motor field coil form; *f*, insulated brush and bus support; *g*, locomotive motor and generator brush-holder stud; *h*, overhead-crane trolley-support insulator, and *i*, diesel-engine governor commutator.

MATERIALS

By Lanier Greer
Consulting Engineer, DC Machinery, and Insulation Co-ordinator
Reliance Electric and Engineering Co.
Cleveland

in combination with the basic resins to form electrical insulating materials and systems are: (1) paper, (2) cotton, as cloth, tape and cord, (3) asbestos, as paper, board or cloth, (4) glass fibers, as roving, mat, and woven cloth and tape, (5) synthetic fibers, as roving, mat and woven cloth and tape, and (6) mica, as natural and synthetic splittings, and also as reconstituted or mica paper. These materials can be used in combination with the basic resins to form flexible and rigid sheet laminates, molded parts, impregnated and coated sleeving, tapes and sheets.

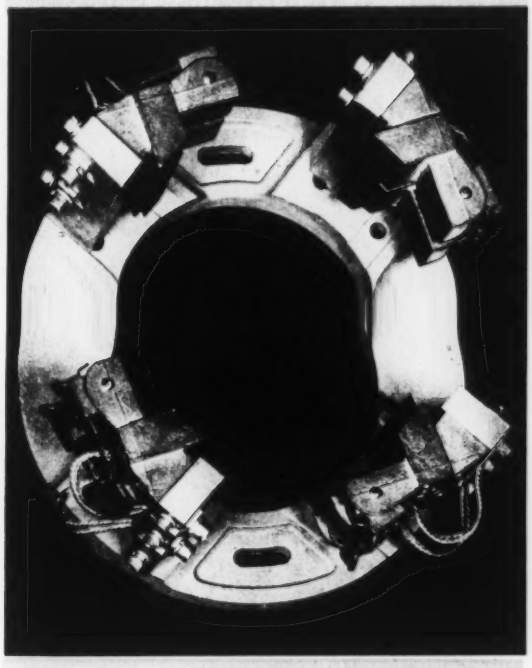


Fig. 2—Rocker ring for dc motor, made of glass-fiber reinforced polyester plastic.

Material Requirements: Requirements for a good electrical insulating material vary with the type of electrical equipment and the application. However, some requirements can generally be used to judge or compare insulating materials or systems. Some of these are:

1. Dielectric strength, usually measured in volts per mil of thickness.
2. Thermal conductivity, usually compared to air.
3. Mechanical strength to stand handling during the manufacture of electrical equipment.
4. Compatibility with other resins and materials used in an insulating system.
5. Thermal life of the material in hours or years at the operating temperature.
6. Flexibility or rigidity, depending on the use.
7. Resistance to arc and to tracking caused by arc.
8. Power factor.
9. Resistance to oil, acids, water and other chemicals which may be encountered.

Major Material Types

Phenolic Resins: Phenolic resins and insulating materials are the oldest of the five major families. Phenolic resins combined with solvents and oils have been used as impregnating or dipping varnishes for many years, in all types of electrical equipment. All of the varnish manufacturers have various grades of phenolic varnish, which is usually about 50 per cent solids. These varnishes require heat or baking to cure, and can be compounded to give any desired finish between very hard and very soft and flexible.

Phenolic resin compounds are used as bonding or laminating agents. Papers and cloths can be bonded under pressure and heat to form sheet, tube and rod laminates that can be machined to any desired shape or size. These laminates are used for insulating washers, terminal boards, slot wedges for dc armatures and ac stators, and for many other purposes where this type of electrical insulation is needed.

The phenolic materials are also applied to cloth,

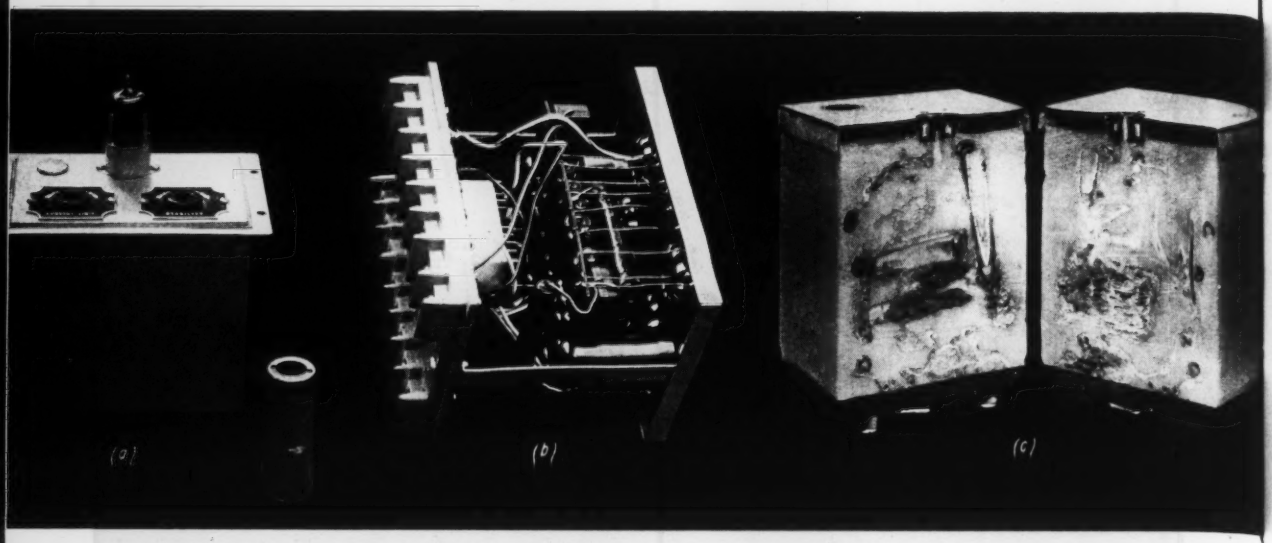


Fig. 3—Unitized Reliance Sealpak control component, *a*, in which all elements except the tube are "potted" in an epoxy resin. A reinforced polyester terminal board, *b*, serves as the base. A cut-apart unit, *c*, shows how the epoxy resin has filled all voids to form a single, sturdy unit.

both cotton and glass, to make flexible sheets that can be used as wrappers or, when slit, can be used as tape for insulating electrical coils. The common materials known as varnished cambric or varnished glass cloth are varnish-impregnated with phenolic-base materials.

Another use for phenolic resin is as a binder in molded pieces of insulation, such as small terminal boards or brush holder insulators for dc machines. These are compression molded to the size and shape required, which reduces machining to a minimum. These molds are filled with phenolic resin and cotton or paper to form the pieces.

In general, the phenolics are good electrical insulating materials when limited to Class A (105 C) temperature, although some formulations are good for higher temperatures. The phenolics have very poor arc resistance.

Polyesters: The polyesters are one of the newer families of resins. They have been tried for electrical insulation for about ten years, and have been widely used for a shorter period. The polyesters are a very versatile family of materials, since they can be modified and compounded with fillers and catalysts to make them suitable for many uses.

The 100 per cent solids polyester materials can be molded to very accurate dimensions with low pressure and at low temperature, Fig. 1. Glass mat and cloth, as well as other materials, are used with polyester resins to make laminates and molded parts, Fig. 2.

In general, the polyesters are good for a temperature between that required for Class A and Class B (130 C) and meet most of the requirements for a good electrical insulating material. They are generally thermosetting materials.

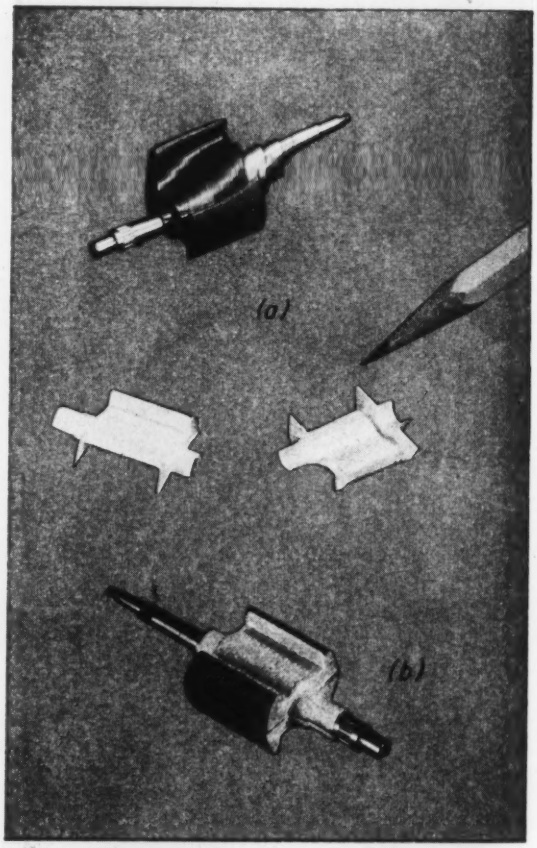


Fig. 4 — Armature from a small motor, *a*, uses silicone-glass laminated insulating parts, *b*.

The polyesters have been formulated into some very unique materials which are very useful as electrical insulations. One of these is Mylar (Du Pont), which is an oriented, transparent flexible material that has high dielectric and mechanical strength and can be formed in films as thin as ¼-mil and as thick as 10 mils. The sheets can be slit to form tape which can be used alone or can be coated with adhesive. It is good for temperatures above Class A but not as high as Class B. So, for Class A temperatures, it is an excellent electrical insulating material. It is also used as a reinforcing material for mica in machines that operate at Class B temperatures. Compatibility of Mylar with other compounds of an insulation system must be evaluated.

A polyester varnish for film-coating copper wire has been developed in the last two years. This material forms a uniform film of electrical insulation on wire when properly applied. So far, it has been successfully used only on round wire. This insulation is good for Class B temperatures, is thin, tough, flexible, and on wire has enough mechanical and abrasive strength for winding. Compatibility of this material with other components of an insulation system must be determined; for example, it is not compatible with all varnishes. With this new development, a film-coated Class B insulated wire is available for the first time. The new varnish is normally about 3 mils thick, whereas the glass-covered wire it replaces is normally about 9 mils thick. With this thinner insulation and Class B temperatures, smaller machines can be manufactured for a given power rating.

Two companies are manufacturing this varnish —Schenectady Varnish Co. under the trade name Isonel, and General Electric Co. under the trade name Alkanex.

Epoxies: The epoxies are perhaps the newest family of resins to be used as electrical insulating materials. These materials—usually thermoplastic —are capable of being compounded in many forms and for many uses. They are used for binders, varnish, laminating glass cloth under pressure and heat, and making molded parts. The epoxies can be compounded to 100 per cent solids or can be used with solvents at lower solid ratios.

Epoxy varnishes have been used to film-coat copper wire. The epoxy coating, however, is not good for Class B temperatures and so loses part of its value, since there are proven Class A materials for coating wire, such as polyvinylformal.

The epoxies have proven to be excellent as potting compounds for control assemblies and coils, Fig. 3. Low shrink and freedom from cracks available from epoxies are good properties for potting or encapsulating.

In general, the epoxy materials are good for Class B temperatures and have high thermal conductivity. They meet the requirements for a good electrical insulating material.

Silicones: Made of semi-inorganic material, the silicone family is good for higher operating temperatures than the other families of resins which have been discussed. In general, the silicones are good for Class H (180 C) or higher.

These resins can be compounded to make impreg-

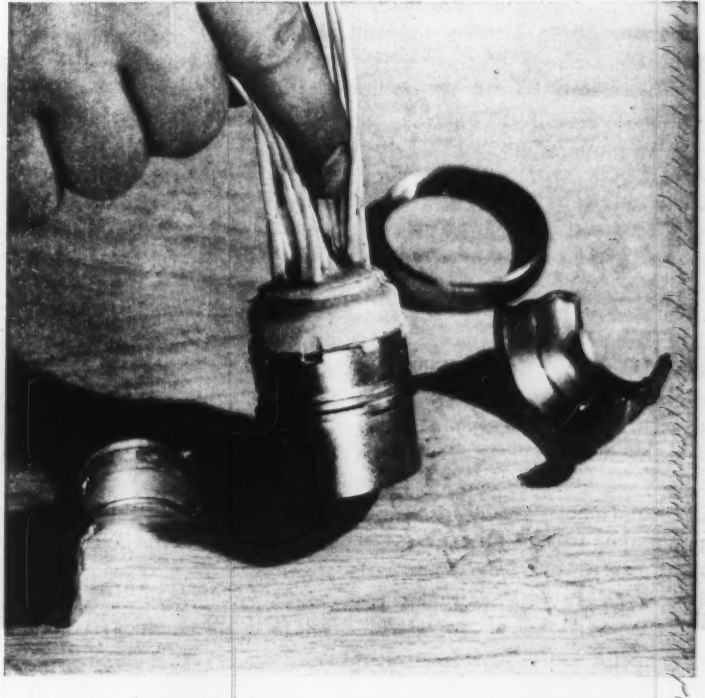


Fig. 5—Silicone rubber used as a potting compound to seal the collar of a Cannon plug, as an experimental project. Silastic RTV was poured into the assembled collar and allowed to cure for two days at room temperature. No special technique was employed, except for lubricating the inside of the collar with soap (Orvus or Dreft) to assure easy, clean release. The silicone rubber provides extra insulation, and also a watertight jacket around and between the wires.

nating varnishes, usually about 50 per cent solids, and to make bonding materials for mica sheets and tapes. Silicone resin can also be used as a bonding material for making laminated sheets and for molding tubes, rods, and other pieces, Fig. 4.

They can also be used for bonding glass fibers to copper wire to form glass-insulated wire for use at Class H temperatures. Much work has been done, with some degree of success, to make a Class H silicone varnish that can be used to film-coat round copper wire, similar to polyvinylformal for Class A or polyester for Class B.

The basic silicone materials can be formulated to make silicone rubber. This material can be vulcanized, extruded, molded, and handled similar to natural rubber. It is used as a tough covering for Class H cable, for leads on many types of electrical equipment, and whenever high-temperature cable is needed. Another use is for ignition cable where high dielectric strength and ability to operate at high temperatures are required. Silicone rubber can be put on glass cloth, and partially cured, then used as a wrapper, or it can be slit and used as tape. After it is put on a coil, the cure can be completed and a sealed coil is formed. Silicone rubber can also be used as a molding or potting material. Fig. 5. Woven glass tubing can be impregnated or coated with silicone rubber to form a flexible tubing with excellent insulating properties.

Use of the silicones as electrical insulating materials at Class H temperatures makes possible smaller electrical machinery with the same or longer useful life. Based on experience, when silicones are used in totally-enclosed and explosionproof dc machinery, the life of the carbon brushes is reduced. Thus, silicones are limited for this use.

Natural and Synthetic Mica: The best grades of mica are mined in India. However, there are deposits of lower grade mica in many other parts of the world—U.S.A., Mexico and Canada, for example. Mica is one of the best-known electrical insulating materials. In its natural state, it is a crystalline structure formed in layers which can be separated to form splittings ½ to several mils in thickness.

These splittings are cleaned and processed with a bonding material, such as one of the basic resin families, into mica plate. This plate is used for insulating heating elements in electrical appliances, commutator parts of dc machines, transformers and other electrical equipment. If mica splittings are bonded with a flexible form of binder and applied to glass cloth, Mylar or other materials of this nature, a flexible laminated sheet is formed which can be used as a wrapper for coils. This sheet can be slit to form a flexible mica tape.

In the past few years, methods have been devised to make mica paper from scrap India mica or from the low-grade micas from other parts of the world. This process is similar to that used to make paper from pulp-wood. The mica paper can be bonded together with a flexible binder made from any of the basic resins and to glass cloth, Mylar, etc., to form flexible sheets or tapes. The mica paper can be bonded with a thermosetting resin to form mica plate. These sheets, plates and tapes can be used in most of the places where mica splitting materials have been used.

Some of the advantages of the mica paper are:

1. Availability at all times.
2. Possible to process to close tolerances.
3. Flexibility is better than mica splittings.
4. More uniform dielectric.
5. More economical for many uses.

Mica crystals have been grown synthetically, under high pressure and heat, by the U. S. Bureau of Mines. This work has been taken over by the Mycalex Corp. of America who are manufacturing synthetic mica in a pilot plant. This plant is being expanded to produce the material on a production basis. The synthetic mica is chemically pure and can be handled and processed in the same manner as natural mica.

What of the Future?

The trend today is toward smaller electrical equipment. Weight and space are at a premium in many applications. Also, in rotating electrical machinery, the trend is toward higher speeds. Economics, as well as the fact that materials are becoming harder to get, are contributing factors.

To make these high-rating machines and equipment, all materials will be worked harder, more accuracy of manufacture will be required, and the highest possible quality of material and workmanship will be essential.

In the future, higher temperature electrical insulating materials will be used because they generally allow the equipment to be smaller. For example, the National Electrical Manufacturers Association has recently set Class B as standard for dc machinery; until now the standard has been Class A. Another example is the use of silicone insulation in dry type transformers.

With these high temperatures, other electrical and mechanical problems are encountered. Mica splittings and paper, as well as glass fiber and asbestos, are materials which are and will be used in combination with the new resins and rubbers in these new high-temperature units and machines.

With the advent of atomic power, another new insulating problem is presented. Electrical machines must be insulated to operate in areas that are "hot" with gamma and other radiation. This opens a whole new field.

New methods of formulating the presently-known electrical insulating materials will be found, and improved products wil be made. Also new materials and systems of materials will be found to help the continued progress of electrical design.

PHOTO CREDITS

Glastic Corp. ..... Figs. 1 and 2
Dow-Corning Corp. ..... Figs. 4 and 5

Military and commercial requirements for high-temperature performance are still going up. The answer to the problem is in new and improved

MATERIALS FOR HIGH TEMPERATURES

Familiar stainless and alloy steels, and high alloys of nickel, chromium and cobalt, are still the basic materials. But competition from ceramics, cermets, and new metals is getting stronger in higher temperature ranges

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DEMAND for materials capable of withstanding higher temperatures and stresses is still increasing. This is true not only for equipment intended for military purposes, such as jet engines and guided missiles, Fig. 1, but also for many commercial applications in the electric-generating, petroleum, and chemical industries. The proposed use of nuclear energy as a source of power is superimposing additional requirements on certain high-temperature materials.

Power Generation

Temperatures in general use today are at a higher level than a few years ago. For example, in steam generating stations, the maximum steam temperature, until fairly recently, was 1000 F. Now 1050 F is common and several stations are operating with a 1100 F temperature. One will soon be operating with a temperature of 1150 F, while another is in the design stage that will use a temperature of 1200 F. Pressures are likewise increasing. In the 1150 F station the pressure will be 4500 psi, and in the 1200 F station, 5000 psi.

In steam generating stations, highest temperatures are encountered in the superheater tubes. Depending upon such factors as rate of heat input and scale formation on the tube walls, temperature differential between the steam and the metal may be of the order of 150 F. Thus, in a 1150 F station, the maximum metal temperature will be about 1300 F and in the 1200 F station, 1350 F. Temperature of the metal piping will be the same as that of the steam.

For metal temperatures up to 1100 F, it is common practice in this industry to use the low or intermediate-alloy steels, Table 1, with the 1¼ and 2¼ chromium grades being the most popular. For metal temperatures of 1100 F and higher, Type 321 has been used for superheater tubes and Type 347 for the steam piping.

For steam temperatures up to and including 1150 F and pressures up to 4500 psi, present alloys on which there has been a considerable amount of experience (the first twelve alloys of Table 1) appear to be entirely satisfactory. In the station soon to be operating under these conditions, Type 347 was used for both the superheater tubing and the main steam piping. At steam temperatures above 1150 F (maximum metal temperatures above 1300 F) there is a question as to whether any of the more standard alloys will have sufficient strength. For the station that is to

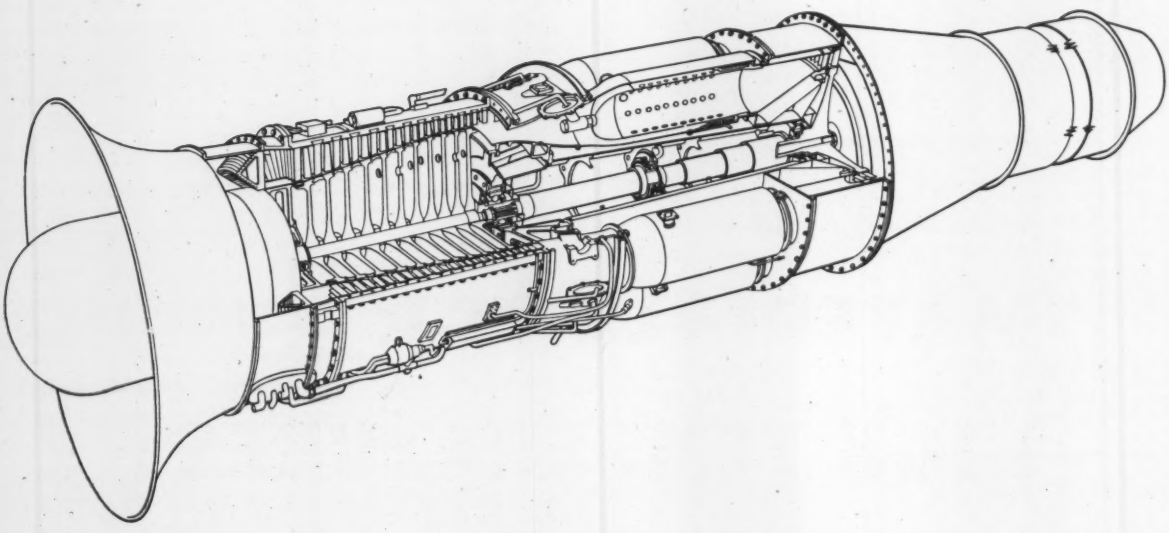


Fig. 1—Typical jet engine requiring high-temperature materials—a J-47 axial-flow turbojet with bellmouth inlet for static testing (National Advisory Committee for Aeronautics).

operate with a steam temperature of 1200 F, consideration is being given to the possible use of some of the more highly alloyed steels listed in Table 1, the so-called "superalloys."

When nuclear energy, rather than coal, oil or gas, is used for the generation of electricity or other power applications, additional metallurgical problems are introduced. Heat is generated at a very rapid rate in the reactor and this heat must be conducted away at a sufficient rate to prevent the reactor from destroying itself. Liquid metals are among the materials being used for this purpose, the most popular being sodium. By means of heat exchangers, the heat from the molten sodium is used to produce steam. The tubes in which the steam is generated must have a high degree of corrosion resistance, for any corrosion products formed might become radioactive and, by circulating through the system, make the entire unit too radioactive for safe application. Alloys used for this purpose are Types 304 and 347, or the extra-low-carbon (ELC) grades of these alloys. There is still a question as to the effect of radiation on the physical properties of the metals and considerable experimental work is in progress on this subject.

Gas Turbines

Insofar as gas turbines for jet engines and industrial applications are concerned, progress is proceeding along two different lines.

In one case, the trend is to permit increased temperatures by use of more highly alloyed materials. Temperatures in the rim of the turbine rotor are on the order of 1200 to 1350 F, and in the blades, 1500 F or higher. Alloys most widely used for the rotors are 16-25-6 and A-286 (alloys 14 and 15 of Table 1). Representative high temperature properties of these alloys are included in Fig. 2. Properties of 16-25-6 are obtained by hot-cold working and, while A-286 is a so-called precipitation-aging alloy, its properties are also enhanced by a certain amount of hot or cold work. The alloys mainly used for blading are S-816, Waspaloy and M-252. These are all highly alloyed materials, and their properties are obtained by precipitation-aging treatments.

The other trend in gas turbines is to hold maximum temperatures at lower levels by proper cooling. Engines are being produced both in this country and in England with maximum turbine rotor rim temperatures on the order of 1100 F or less. Steels of the Rex 448 type are widely used in England and those of the "17-22-A"S type, or its modifications, in this country. At least one engine in this country also uses "17-22-A"S, in the form of sheet and rolled rings, for the outer combustion chamber and tail-cone assembly. Protective coatings, such as aluminum, are used to increase oxidation and corrosion resistance of these lower alloyed steels.

Temperatures are also increasing in compressors of the newer jet engines. Metal temperatures at

the outlet are on the order of 800 to 900 F and may even reach higher levels in some of the newer designs. Aluminum or titanium is used in the lower-temperature sections, and steels of the 410 and "17-22-A"S types in the hotter zones. Type 410 is one of the steels commonly used for blading in these compressors, although in some cases "17-22-A"S is being used.

For gas turbines in which some cooling is used to reduce maximum temperature, present alloys are capable of rendering satisfactory service, although a field does exist for low alloyed materials, or those of the 410 type, that will possess a 1000-hr rupture strength at 1200 F on the order of 30,000 to 40,000 psi. In other words, the ability to extend operating temperatures by 100 F would be desirable. For those gas turbines in which maximum possible temperatures seem to be desired, the demand will probably never be completely satisfied. Regardless of what temperature level is attained, still higher temperatures will be wanted.

In order to extend the temperature above 1500 F, considerable work is in progress on ceramics, generally carbides, oxides, or silicates. While certain of these materials have good high-temperature strength, they are often very brittle and their use involves new concepts of design. Attention is also being given to the use of cermets—mixtures of ceramics (such as titanium carbides) with metals (often either cobalt or a combination of cobalt with nickel). These hold considerable promise but are still in the development stage.

The more promising of the newer materials appear to be the molybdenum-base alloys. Certain of these, on the basis of work to date, have indicated strengths of a high order of magnitude at temperatures up to 1800 F. However, their oxidation resistance is very low, and thus their surface must be protected by an oxidation-resistant material capable of some deformation without cracking.

Aircraft and Missiles

Extremely high temperatures are likewise involved in rocket-engine aircraft and supersonic missiles. Because of frictional effects, the skin temperature of outer structural parts may reach temperatures above the melting point of the common metals when moving at speeds on the order of 2000 mph. One of the approaches to this problem could be the use of multiple skins which burn off during flight. Another would be the use of nonmetallic materials, such as the cermets previously referred to, or the higher melting metals, such as molybdenum, chromium or tantalum.

One of the disturbing factors with respect to high-temperature alloys is the continually recurring shortage of nickel. From Table 1 it will be seen that all of the high-temperature alloys, with the exception of the first nine, contain large amounts of this element. While the government's stockpiling program for this metal may assure sufficient supplies for military purposes, it does not for commercial applications. As of now, industry largely depends on the 18 Cr, 8 Ni type alloys (alloys 10 through 13 of Table 1) for temperatures in excess of 1100 F.

Attempts are now being made to correct this

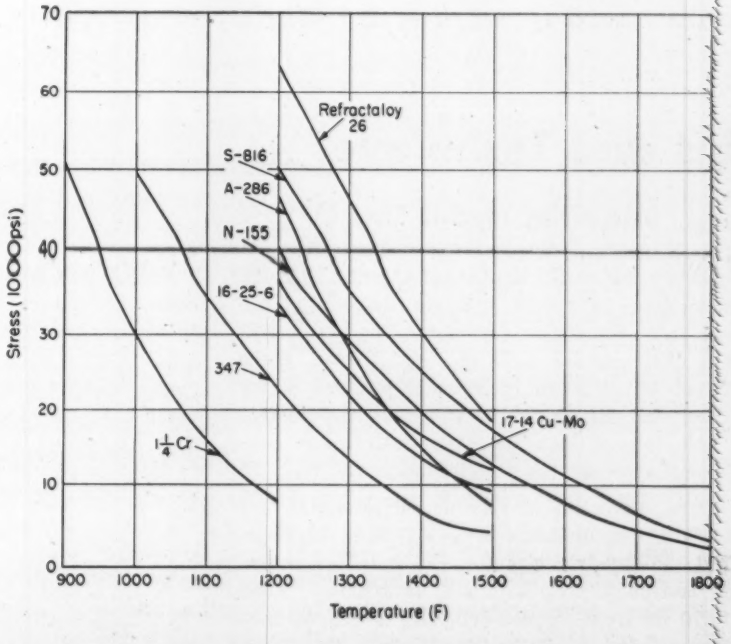


Fig. 2 — Rupture (1000 hr) of selected high-temperature alloys (average values from ASTM special publication 160).

Table 1—Typical High-Temperature Metals

	Type	C	Mn	Si	Cr	Ni	Mo	V	Co	Others
Low and Intermediate-Alloy Steels										
1.	1¼ Cr	0.15	0.50	0.75	1.25	....	0.50	...	....	...
2.	2¼ Cr	0.15	0.50	0.50	2.25	....	1.00	...	....	...
3.	3 Cr	0.15	0.50	0.50	3.00	....	1.00	...	....	...
4.	5 Cr	0.15	0.50	0.50	5.00	....	0.50	...	....	...
5.	7 Cr	0.15	0.50	0.75	7.00	....	0.50	...	....	...
6.	9 Cr	0.15	0.50	0.75	9.00	....	1.00	...	....	...
7.	"17-22-A"S	0.30	0.50	0.65	1.25	....	0.50	0.25	....	...
8.	410	0.15	1.00	1.00	12.00	....	....	...	....	...
9.	Rex 448	0.10	0.50	0.50	11.00	....	0.70	0.25	....	0.50 Cb
Chromium-Nickel Austenitic Steels										
10.	304	0.08	2.00	0.75	18.00	11.00	....	...	....	...
11.	321	0.08	2.00	0.75	18.00	12.00	....	...	....	0.45 Ti
12.	347	0.08	2.00	0.75	18.00	12.00	....	...	....	0.90 Cb
13.	316	0.08	2.00	0.75	16.00	13.00	2.50	...	....	...
14.	16-25-6	0.10	1.35	0.70	16.00	25.00	6.00	...	....	0.15 N_2
15.	A-286	0.05	1.35	0.95	15.00	26.00	1.25	0.30	....	2.0 Ti, 0.20 Al
16.	17-14 Cu	0.12	0.75	0.50	17.00	14.00	2.50	...	....	3.0 Cu, 0.50 Cb, 0.25 Ti
Chromium-Nickel-Cobalt Austenitic Steels										
17.	N-155	0.15	1.50	0.50	21.00	20.00	3.00	...	20.00	2.5 W, 1.0 Cb
18.	S-590	0.40	1.50	0.70	20.00	20.00	4.00	...	20.00	4.0 W, 4.0 Cb
19.	S-816	0.40	1.50	0.70	20.00	20.00	4.00	...	43.00	4.0 W, 4.0 Cb
20.	Refractaloy 26	0.05	0.70	0.70	18.00	37.00	3.00	...	20.00	2.8 Ti, 0.20 Al
Nickel-Base Alloys										
21.	Inconel X	0.04	0.70	0.30	15.00	73.00	....	...	....	0.9 Cb, 2.5 Ti, 0.9 Al
22.	Waspaloy	0.05	0.70	0.40	19.00	58.00	3.00	...	14.00	2.5 Ti, 1.2 Al
23.	M-252	0.10	1.00	0.70	19.00	54.00	10.00	...	10.00	2.5 Ti, 0.75 Al
Cobalt-Base Alloys										
24.	Vitallium	0.25	0.60	0.60	27.00	3.00	5.00	...	62.00	...
25.	X-40	0.40	0.60	0.60	25.00	10.00	....	...	55.00	8.0 W

condition by developing alloys with a maximum of 3.0 or 5.0 per cent nickel, or with none at all, that will have satisfactory high-strength properties above 1100 F. The AISI has recently announced two new grades of stainless steels, designated as Types 201 and 202. Their analyses are:

Type	*C*	*Mn*	*Si*	*Cr*	*Ni*	*N_2*
201	0.15 max	5.5-7.5	1.0 max	16.0-18.0	3.5-5.5	0.25 max
202	0.15 max	7.5-10.0	1.0 max	17.0-19.0	4.0-6.0	0.25 max

In these alloys, a large portion of the nickel has been replaced by manganese, and nitrogen has been added to assist in keeping the alloy completely austenitic and to help the high-temperature strength. The ability of an alloy to retain nitrogen appears to be a function of manganese content; development work is now underway in which the nickel is completely replaced by manganese and nitrogen. In one of these newer experimental alloys, manganese content is on the order of 15.0 per cent and nitrogen about 0.50 per cent. This alloy is reported to have a 1000-hour rupture strength at 1200 F somewhat superior to Type 347.

Tips and Techniques

Determining Tap-Drill Sizes

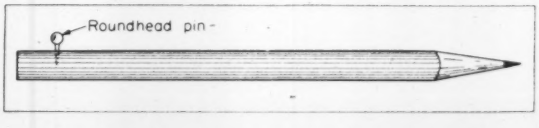
To determine easily the proper tap-drill size for special pitches of thread, subtract the pitch of the thread from the major diameter. The result will give a drill size for a 77 per cent thread. Since a 75 per cent thread is common practice, using the next largest drill size will give the correct size hole.

Examples: Find the tap-drill size for a ⅞-16 NS screw. Pitch for 16 threads per inch is 0.0625 or 1/16-in. Tap drill size is ⅞ −1/16 = 13/16-in.

Find the tap-drill size for 1⅛ x 18 NS screw. Pitch is 0.0555. Tap drill size is 1.125 − 0.055 = 1.070 in. Next largest drill size is 1 5/64-in.— C. STUART EDGAR, *Union Twist Drill Co., Rock Island, Quebec, Canada.*

Pencil Roll Stop

Pencils rolling off a tilted drawing board can cause no end of annoyance, particularly if the point must be resharpened. A small pin, preferably a round-head map pin, may be pressed into the pencil a short distance from the end. This prevents the pencil from rolling and will not interfere with its normal use. A color code may be devised to identify pencils of various hardness. — ROGER ISETTS, *Kenosha, Wis.*



HIGH-STRENGTH ADHESIVES for Metal Bonding

An engineering review of current requirements for adhesives, bonding-process specifications, and joint design.

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ALTHOUGH adhesives have been used for bonding substances such as wood and paper for hundreds of years, they have only recently come into their own as important engineering materials.

This recent change in status is largely the result of (1) evolutionary developments over a period of years in the gluing of wood and similar materials where high-strength joints have been utilized for many years, (2) the development of new synthetic resin and rubber raw materials, and (3) the great need for more efficient, lower cost, more reliable, and lighter and stronger assemblies than possible with mechanical fastenings. The increased interest in sandwich constructions of thin metal or plastic faces bonded to lightweight

Advantages of Adhesive Bonding

1. Permits joining of certain materials not otherwise possible or practical. Example: sandwich panels with honeycomb cores and thin plastic or metal faces.
2. Permits joining two or more similar or dissimilar materials economically.
3. Permits joining materials where mechanical fastenings are less suitable. Example: bonded brake and clutch linings to avoid possible damage from rivet heads.
4. Transfers stresses more efficiently from one member to another than mechanical fastenings, and can reduce fatigue failures. Example: structural aircraft joints, glued trusses.
5. Permits design of smoother joints in composite articles. Example: reduces weight and air drag by bonding, rather than riveting, aircraft control surfaces.
6. Reduces corrosion in joints of dissimilar metals. Example: reduces galvanic action between steel and aluminum when they must be joined in aircraft.
7. Provides better sealing action than mechanical fastenings. Example: bonding metal extrusions to seal edges of sandwich panels.

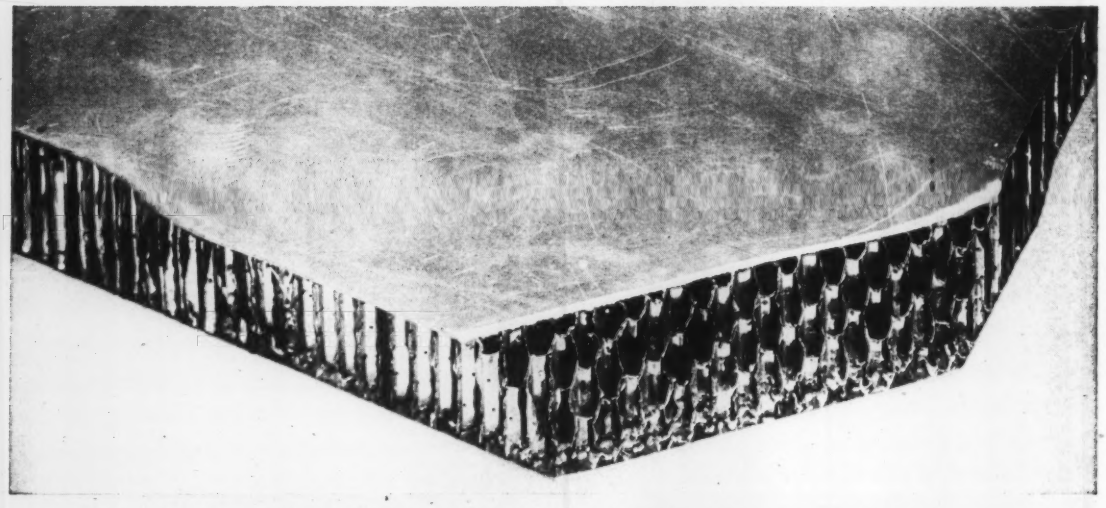

Fig. 1—Typical flat sandwich panel with thin metal faces and metal honeycomb core, bonded with a structural type adhesive.

honeycomb cores of metal, paper or impregnated fabrics, Fig. 1, has been another important reason for the development of these new structural adhesives.

Unusual requirements in the design and fabrication of modern high-speed aircraft and missiles, Fig. 2, have also been a powerful factor in stimulating the recent development of high-strength metal-bonding adhesives. This article is limited to these types. However, similar important recent developments in high-strength adhesives for bonding wood, paper, plastics, rubber, and many other materials to themselves or each other should not be overlooked.

Types of Metal-Bonding Adhesives

It is now possible to bond metals with a variety of adhesives. Solvent-type, rubber-base cements are available for bonding metals at room temperature or by application of moderate heat. The rubber base may be natural, synthetic or reclaimed rubber. Such adhesives give relatively low to moderate strength, but are rapid and easy to use. They are widely used for bonding metal or plastic laminate sheets to wood or to metal for various architectural and furniture panels not subjected to high stresses in the joints. These solvent-type rubber cements are also used for attaching rubber or vinyl sheets to metals in automobiles and appliances.

Casein-latex, natural and synthetic rubber latex, and polyvinyl acetate and copolymer emulsions are also available for bonding metals to porous surfaces, such as wood or paper, but not to another metal surface. One porous surface is always necessary to permit absorption of water to break the emulsion and permit rapid setting.

While these solvent-type adhesives are easy to use and economical, none are considered to have the desired combination of high strength and permanence that makes them suitable for critical applications such as structural bonds for aircraft.

Adhesive types listed in Table 1 were developed specifically for modern aircraft design requirements. Most are based on phenol resins, which are also widely used to provide strong, durable joints for wood. These resins are combined with certain elastomers or thermoplastic resins to improve adhesion to metals and reduce brittleness and stress concentrations in the joints.

With the exception of the epoxy-resin adhesives, all of these adhesives require pressing and curing at 275 to 350 F for periods of 10 to 30 minutes or longer. Epoxy resins have been formulated that will cure at normal shop temperatures over a period of several hours or days but, like all thermosetting resins, they will cure faster and more completely at higher temperatures. Each type of adhesive requires somewhat different bonding procedures.

Selection of the best adhesive for a new application will involve a consideration of:

1. Materials being bonded. The adhesive must wet the surfaces and adhere to them.

2. Design of the joint and the initial level of strength required. Shear, tensile, cleavage, and peel forces must be considered.

3. Service life expected of the bonded joint. The adhesive bond may need resistance to heat, moisture, oils, chemicals, or fatigue.

4. Working properties and bonding requirements of the adhesive. Methods of application, temperature and pressure required, and speed of curing are important factors for economical production. Adaptability of the adhesive process to existing bonding equipment, and the need for additional equipment must be considered. Personnel requirements for production and inspection may differ for different bonding processes.

5. Cost. This factor includes cost of the adhesive, preparation for use, the bonding operation, waste, and probable rejects.

Generally, all of the newer adhesives can produce joints of high initial strength when used under proper conditions. One principal difference between the adhesive types is in resistance to thermal aging and strength of the joints at elevated temperatures, where epoxy and phenol-vinyl adhesives tend to soften more than the others. Epoxy resins soften excessively above 200 F, and phenol-vinyl adhesives begin to lose much of their initial strength when tested at about 250 F. Phenol-neoprene adhesives are somewhat better in resistance to heat softening than are the phenol-vinyl combinations, but they lack resistance to heat aging at higher temperatures. Phenol-Buna N and phenol-epoxy resins appear to be the most promising adhesives at present for service initially and over periods of 100 hr or so at 450 F or higher. These temperatures are of current interest for high-speed aircraft and missiles, where adiabatic heating during flight is a critical problem.

The Bonding Process

Regardless of the type of structural adhesive selected, the bonding process is quite similar in principle, although somewhat different in degree, and is worth comment here. Several steps are involved. Quality of any adhesive-bonded joint will depend both on the adhesive itself and on the care with which the bonding process is performed.

Metal Preparation: The adhesive must adhere strongly to the metal. This adhesion is now believed to involve electrochemical forces, the exact nature of which is not yet well understood. It is generally considered that for high-strength durable bonds with these modern structural adhesives, something more than simple cleaning and degreasing of the metal surface is necessary. A variety of procedures have been studied for preparing the surface of aluminum, stainless steel, magnesium and titanium alloys for bonding. Procedures vary from simple abrasion and solvent degreasing to electrolytic treatments, alkaline and acid etching, and combinations of these. In order to have both consistently high initial strength and good resistance to moisture, salt spray and weathering, some sort of chemical or electrolytic treatment is generally required for metals such as clad aluminum or stainless steel.

There are some recent indications that surface preparation may be more important in affecting thermal aging characteristics of the metal bond than in just affecting the initial strength at room temperature. With reactive metals such as magnesium alloys, the process for preparing the surface for bonding must be integrated with the process for protecting the surface from corrosion in later service.

Application of Adhesive: Originally, all metal-bonding adhesives were solutions of a rather low solids content in volatile organic solvents. One or more coats of these solutions were applied to each of the two mating surfaces by spraying, roller coating or other means to build up the required film thickness.

Release of entrapped solvents from these succes-

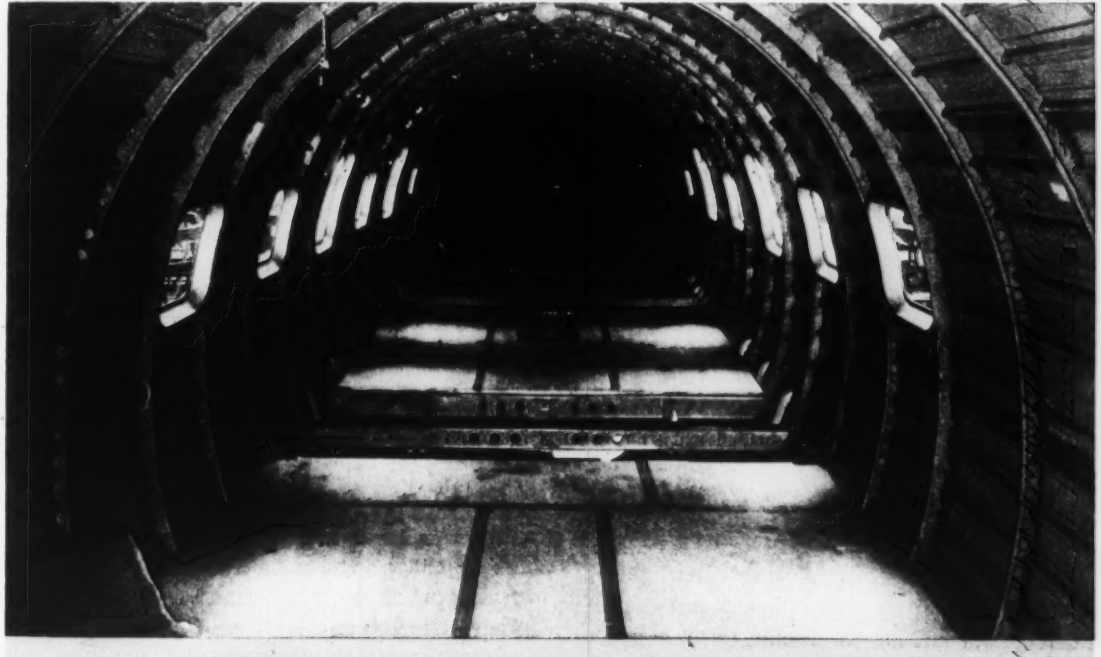

Fig. 2—Metal stringers (running lengthwise) synthetic-resin-bonded to fuselage skin of airplane to keep weight low (Ciba Co. Inc.)

sive layers has always offered problems, since films tend to skin over, which interferes with further volatilization. Cooling, as a result of fast solvent evaporation, sometimes caused excessive condensation of atmospheric moisture in the film, which reduced bond quality with some adhesives. Entrapped solvent caused excessive flow and increased blistering in subsequent pressing, and tended to reduce heat resistance of the joints. Force drying and precuring techniques at elevated temperatures have been developed to overcome this problem.

Epoxy-resin adhesives are of particular interest here because of their unusual chemical makeup. They can be supplied as completely reactive resin systems in liquid form without volatile solvents or byproducts of curing. This not only avoids the blisters and precuring problems but also permits use of lower bonding pressures.

Recently there has been considerable development of adhesives in the form of supported or unsupported tapes that can be laid between two metal surfaces like a sheet of paper and then pressed immediately. Some tapes, however, give better results when the metal surfaces are first primed with a thin coat of a separate liquid adhesive.

Curing: All adhesives containing thermosetting resin components will develop their strength and permanence at least in part by undergoing a chemical reaction called curing, the rate of which increases with temperature. The joint must, of course, be under sufficient pressure during curing to produce the flow necessary to cause adequate and uniform wetting of all surfaces. Pressure must then be retained until the adhesive has hardened and developed strength to resist stresses after removal from the press.

Some phenol-vinyl, epoxy and phenol-epoxy resins flow adequately at rather low pressures, while the phenol-neoprene and phenol-Buna N types generally require pressures of 150 psi or higher at the 275 to 350 F curing temperature. Assemblies can generally be removed from the press without cooling as soon as pressure is released. Actual bonding pressure will depend somewhat on joint design. Pressures must be lower on honeycomb-core sandwich panels than on metal-to-metal laminates to avoid crushing the core.

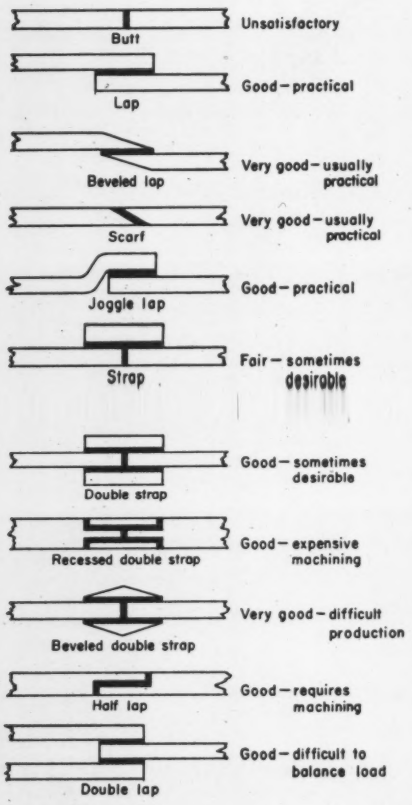

Fig. 3—Good and poor joint design with metals bonded with structural adhesives, and suggested methods for improving joint performance (Reference 17).

Joint Design and Current Applications

Much attention has been devoted in recent years to joints designed to take better advantage of the properties and limitations of new structural adhesives. The simple lap specimen is still the most common test specimen used to evaluate metal-bonding adhesives. But it is recognized that pulling such a joint in tension may produce excessive eccentricities in the bonded joint and does not permit the adhesive to demonstrate its greatest potential.

Redesigning this lap joint with beveled or scarfed edges, or the use of double straps, Fig. 3, will greatly increase the observed joint strength. Additional consideration of joint design with adhesive bonding is desirable to expand the potentials of such structural bonds further.

Adhesive bonding of metals has been of particular interest in the design of sandwich panels that have thin metal skins on lightweight honeycomb cores of aluminum, paper, or fabric impregnated with polyester or phenol resins, Fig. 1. Such sandwich panels provide lightweight, stiff and strong structures that are being utilized for floors and control surfaces on aircraft, fins on missiles, lightweight building panels, truck-trailer panels, special shipping containers, and a number of other applications where the weight saving is particularly attractive.

Other important applications of structural adhesives are currently in use or under study for aircraft applications. These include the bonding

Table 1—Typical Metal-Bonding Adhesives for Structural Applications

Type	Typical Trade Names	Manufacturer	Location	Available as . . . Liquid	Tape	Cure at . . . . . Room Temp.	275 to 375 F
Phenol-vinyl	Cycleweld	Cycleweld Cement Products	Trenton, Mich.	Yes	Yes	No	Yes
	Bloomingdale	Bloomingdale Rubber Co.	Chester, Pa.				
	Bondmaster	Rubber and Asbestos Corp.	Bloomfield, N. J.				
	Bostik	B & B Chemical Co.	Cambridge, Mass.				
	Redux	Ciba Co. Inc.	New York				
	Plycozite	U. S. Plywood Corp.	New York				
Phenol-Buna N	Armstrong	Armstrong Cork Co.	Lancaster, Pa.	Yes	Yes	No	Yes
	Bloomingdale	Bloomingdale Rubber Co.	Chester, Pa.				
	Plastilok	B. F. Goodrich Co.	Akron, Ohio				
	Bondmaster	Rubber and Asbestos Corp.	Bloomfield, N. J.				
	3M	Minn. Min. & Mfg. Co.	Detroit, Mich.				
	Cycleweld	Cycleweld Cement Products	Trenton, Mich.				
Phenol-neoprene	Metlbond	Narmco Inc.	Costa Mesa, Calif.	Yes	Yes	No	Yes
	Cycleweld	Cycleweld Cement Products	Trenton, Mich.				
	Bondmaster	Rubber and Asbestos Co.	Bloomfield, N. J.				
Epoxy	Epiphen	Borden Co., Chem. Div.	New York	Yes	No	Yes	Yes
	Cycleweld	Cycleweld Cement Products	Trenton, Mich.				
	Epon	Shell Chem. Corp.	New York				
	Hysol	Houghton Labs Inc.	Olean, N. Y.				
	Araldite	Ciba Co. Inc.	New York				
Phenol-epoxy	Aerobond	Hexcel Products Inc.	Oakland, Calif.	Yes	Yes	No	Yes
	Epon	Shell Chemical Corp.	New York				

*This list of commercial products is necessarily incomplete and is included only for example. A number of other firms make similar adhesives of each type.

of a variety of metal stiffeners to thin metal skins to stiffen the skins without excessively increasing weight, and the laminating of several thinner flat metal sheets into a thicker curved section, such as the leading-edge surface of a wing. In the curved section, bending, tapering of the cross section and bonding are accomplished in one operation. In many small but critical fastening applications, adhesive bonding offers the only practical method of joining materials.

Efficient transfer of stresses from one member to the next by adhesive bonding, thus reducing much of the stress concentration that would be produced at conventional mechanical fastenings, has been found to improve the fatigue properties of assemblies greatly. Such adhesive bonding has been reported to be of particular importance in increasing the service life of metal helicopter rotor blades by reducing excessive and early fatigue failures.

The Future

There seems to be little doubt that the use of structural metal-bonding adhesives will increase greatly in the next few years. Developments in the aircraft industry during the past four years illustrated how rapidly use of such adhesives is spreading to increasingly critical applications where stresses are higher and temperatures and other service requirements more severe. Certainly, the presently available adhesives are not the final answer. Adhesive chemists and technologists are continuing their search for better bonding processes that are simpler and cheaper to use, more reliable, and more versatile.

Designers are learning more about the basic strength properties of adhesives. Studies are underway to determine more exactly the reproducibility or uniformity of bonds with different bonding processes to permit selection of more realistic margins of safety. Considerable effort is being directed towards development of more adequate inspection methods for the bonding process and for the final bonded products, such as proof testing and nondestructive test apparatus. All these efforts will unquestionably produce adhesive-bonding processes that will permit more complete utilization of the enormous potentials of adhesive bonding.

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Basic design principles and practices in selecting

CORROSION-RESISTANT

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THE TERM "corrosion resistance" is a somewhat misleading expression. In all sincerity one could make the statement, for example, "Mild steel has good corrosion resistance, but aluminum has very poor corrosion resistance." To a design engineer, such a remark might come as a rude shock. A corrosion specialist, however, would reply, "Oh, you mean in alkaline solutions."

This points up the extreme importance of the environment to which a metal is exposed. Actually, all metals corrode to some degree. In some mediums the corrosion product is a very thin, sometimes transparent coating, usually of the metal oxide. If this coating is reasonably continuous, adherent, and inert to the environment, the metal undergoes little further attack. Under these conditions, the metal is called "corrosion resistant." If, on the other hand, the very same metal is in another environment, into which the corrosion product is steadily dispersed, continuing and more or less rapid metal destruction will occur.

The corrosion engineer studies and tabulates the almost limitless combinations of metals and corrosive environments. A great many such tabulations are available and are quite useful to the designer. In this article, however, only the broadest qualitative picture of metals and their suitability to various environments will be given, since designing for severe or unusual corrosive conditions involves the close co-operation of a specialist.

A Little Theory

It is a basic fact of nature that practically all structural metals show a thermodynamic preference not to remain metallic at all! Metal structures can be built with reasonable permanence only because nature (aided by man) has put up some fairly effective roadblocks against reactions between metals and their environment. In other words, when the *rate* of reaction between a metal and its surroundings is sufficiently low, the metal is called "corrosion resistant."

Anodes and Cathodes: It is now well established that the reaction between a metal and a solution consists of two "half-reactions." The first is the actual "oxidation" of the metal, whereby it loses its metallic nature (gives up electrons) and becomes a salt or an oxide; the site of this reaction is termed the *anode.* A simultaneous "reduction" reaction must accompany the oxidation; it occurs at the *cathode,* where electrons are consumed. The extent of the anodic reaction is always exactly equivalent to the cathodic reaction; i.e., the electrons produced at the anodic site are matched precisely by those consumed at the cathodic site. A typical cathodic reaction is the reduction of oxygen to hydroxyl ion.

Sometimes the anodes and cathodes are distributed rather widely over a surface; the corrosion process is then known as *pitting.* When they are spaced fairly closely, the attack is known as *general corrosion.* In all cases, however, the corroding metal surface might be compared to a large number of short-circuited cells; the total quantity of current flowing corresponds exactly to the rate of metal destruction.

When two dissimilar metals in contact are exposed to the same body of corrosive medium, conditions are frequently conducive to *galvanic* corrosion. Usually one metal assumes the role of cathode and the other functions as an anode. The mechanism of the corrosion process is the same, however, whether one or more metals are

STRUCTURAL MATERIALS

and an up-to-date report on

1. **Corrosion-prevention methods**
2. **Available metals**
3. **New materials**

involved. In fact, the presence of dissimilar metals does not automatically cause corrosion to occur, as is commonly believed.

How Is Corrosion Prevented?

Speaking very generally, the techniques to avoid corrosion are:

1. Use a metal whose corrosion rate is inherently sufficiently low to give adequate service life.
2. Interfere with the corrosion process by one of the following methods:
   a. Coat the metal with an inert material (e.g., paint).
   b. Coat the metal with another metal whose corrosion resistance is sufficiently low (plating).
   c. Use cathodic protection to provide an auxiliary anode at which all the oxidation will take place preferentially (e.g., magnesium in a water heater).
   d. Use inhibitor chemicals which, when added to the corrosion medium, impede the progress of either the anodic or cathodic reaction (e.g., chromates, nitrites, etc.).

Since this article is concerned primarily with structural materials, discussion will be limited mostly to method 1.

What Metals Are Available?

Usually, several requirements must be met in the selection of a metal for service in a machine in addition to corrosion resistance. In fact, considerations of strength, hardness, toughness, antifriction properties, lightness, ease of fabrication, cost, and many others are normally placed above corrosion resistance. Since the design engineer is usually well-provided with tables of physical properties, only the general corrosion properties of the various metals will be reviewed.

It is only fair to state immediately that requirements of cost and strength must in many instances dictate the choice of a structural metal. If the supply of all metals were unlimited, a great many devices could be engineered to last indefinitely as far as corrosion is concerned.

A quick look at the common metals is in order before discussing new and improved materials. Actually, few metals are sufficiently available to be called "structural" materials. Many metals, of course, are used in specific applications where their corrosion properties are so superior that their cost is of minor concern; some of these will be mentioned later.

Table 1 summarizes in quite abbreviated form the approximate performance of the common metals and alloys in the most frequently met environments. It should be pointed out immediately that many of the *G* entries would be *E* if surface appearance were of no consequence. For example, copper and many of its alloys give very satisfactory service in all of the media listed. One must admit, however, that a copper article develops a rather definite tarnish, even in indoor exposure.

The general rule for selection of a corrosion-resistant metal is: Use the one which costs least and gives satisfactory service. In this day of extreme cost-consciousness, some of the older manufacturing practices are very interesting, if not astounding. For example, during the 1930's a large number of household water meters were supplied to Mexico—made entirely of solid nickel! Another example, perhaps not so dramatic, is the gradual substitution of aluminum for copper in power lines—dictated almost solely by the relative

price of copper and aluminum.

It is evident from Table 1 that two of the most plentiful metals—iron and magnesium—are, unfortunately, the poorest in corrosion resistance. Among the others, copper, nickel, silver and tin are frequently too expensive to be considered as substitutes for steel—even when their physical properties are sufficiently good. Stainless steel is excellent, but may be costly. This leaves aluminum, lead and zinc. In certain applications where its low physical strength is not a limitation, lead serves admirably. Similarly, in a great many applications where appearance is unimportant, zinc offers many advantages over steel—including ease of fabrication.

In passing, it should be pointed out that zinc in the form of die-castings has been made to appear much less corrosion-resistant than it really is. It is widely recognized that the application of relatively thin copper-nickel-chromium plating to a zinc part (which improves appearance temporarily) leads to pitting-type corrosion which is not at all characteristic of zinc alone.

The last—but not least—metal on this list is aluminum. Fortunately, nature seems to have provided a large supply of the metal and, at the same time, some rather effective natural barriers against corrosion and tarnishing.

What Improvements Can Be Expected?

A most pertinent question to ask after glancing at the cost figures in Table 1 is, "Why aren't new iron, zinc, or magnesium alloys developed which will bring these metals into the corrosion category of copper, nickel or stainless steel?" To answer this, one must risk being called pessimistic, or at least unimaginative. Knowing the unexpected turns which Nature frequently takes, it must be admitted that a rust-proof structural steel is possible, or a completely corrosion-resistant zinc or magnesium alloy may be discovered.

The weighty evidence of experience, however, points to only minor improvements in the performance of a given metal class. The difference between a *G* and a *P* in Table 1 frequently reflects a manyfold difference in corrosion performance. To expect a small change in composition to produce the required dramatic change in corrosion properties seems over-hopeful. In fact, for many nearly pure metals, corrosion resistance is reduced by minor additions of other elements.

Within a given class, of course, quite significant improvements have been made. In the early applications of aluminum alloys to aircraft, for example, the phenomenon of stress-corrosion cracking was encountered. Through minor compositional changes this problem has been brought under control. Similarly, early zinc die castings were quite unsatisfactory until it was discovered that lead and tin must be excluded in order to avoid early disintegration of the metal.

Even in the stainless steel group, alloys have been discovered with somewhat improved resistance to pitting in chloride solutions (Type 316). Magnesium has likewise been improved, largely through establishment of maximum impurity limits. The structural steels vary considerably in atmospheric corrosion resistance—or perhaps, more accurately, in ease of protection. A new steel is reported to have even better physical properties than structural silicon steel and twice the resistance to atmospheric corrosion (Man-Ten, A-242).

These brief examples illustrate the fact that, even with considerable improvement, each class of metal generally remains in its position relative to the other metals.

It is another story, however, when a new class of alloys is developed which utilizes relatively large proportions of two or more metals. Stainless steel itself is a classic example. Here the corrosion properties of chromium are imparted to an iron-base alloy containing more than 70 per cent iron. Similarly, nickel-chromium and nickel-copper alloys can show marked improvement over either metal alone in specific media.

At the present time, most alloy development

Table 1—Corrosion Resistance of Common Metals

Metal or Alloy	Cost ($/lb)	Indoor	Outdoor			Tap Water	Mild Alkalies	Mild Acids	Sea Water
			Urban	Rural	Marine				
Aluminum and alloys	0.26-0.56	E	G	E	F	G-F*	P	P	G-F*
Copper and alloys	0.45-0.86	G	G	G	G	G	G	G	G
Iron and steel	0.04-0.13	F	P	P	P	P	G	P	P
Lead	0.16-0.22	G	G	G	G	G-F	P	G-P	G
Magnesium	0.31-0.63	F	P	F	P	P	G	P	P
Nickel and alloys	0.64-1.22	E	G	G	G	E	E	G	G
Silver	11.00	G	G	G	G	G	G	G	G
Stainless steels	0.21-0.83	E	G	E	G	G	E	G	P*
Tin	1.02-1.20	G	G	G	G	E	P	P	G
Zinc	0.14-0.24	G	G	G	G	F	P	P	F

E—Excellent, service and appearance. F—Fair, service. *Frequently pits.
G—Good, service. P—Poor, service.

work seems to be directed primarily at high-temperature materials, and quite understandably so in this jet age. There is reason to believe, however, that much progress can yet be made in everyday structural metals. The number of metallic elements in the periodic table is admittedly limited, but the number of combinations which remain to be tested is astronomical.

New Metals

Titanium has not yet been mentioned. This metal may move rapidly to the forefront in structural applications. Its strength-weight ratio and other physical properties have made it extremely useful in the military picture. Unfortunately, its cost is still too high to permit general substitution for steel, aluminum, or other conventional metals in non-military applications.

The corrosion resistance of titanium is indeed novel. It resists all of the common environments, including salt atmosphere and sea water. Its appearance is somewhat similar to stainless steel.

Another metal which has emerged during the last several years as a very useful corrosion-resistant material is zirconium. The physical properties of the zirconium nucleus have made it extremely valuable in the construction of atomic reactors. Coupled with its non-neutron-absorbing property is a very remarkable resistance to hot water as well as to most common environments. Again, cost prohibits its general adoption where other metals can be used.

Must Metals Be Used?

It was very unfortunate that plastics as a class were utilized so badly in many of their early applications. When they are properly engineered, there are a great many instances where direct substitution of an organic plastic material for metal can be achieved. The extreme resistance to corrosion afforded by such materials as nylon, polyethylene, Teflon, and many other plastics needs no emphasis. The problem has been to achieve the physical properties to which we have been accustomed with metals, or to design around the lower strength inherent in organic materials.

One group of plastics is still rapidly developing —reinforced plastics. There is almost no limit to the variety of properties which can be obtained from combinations of high-strength materials, such as steel or glass, and flexible, corrosion-resistant materials made from various organic compounds.

One of the most interesting potentialities in this field of composite materials stems from the concept of "fiber metallurgy." For years, the use of structural metals in the form of sheet, rod, tubing, castings, etc., has been familiar. In recent years, the technique of powder metallurgy has joined the other fabrication methods. Now a newcomer promises to provide still another class of materials for the designer to consider—fiber-metal bodies.

Briefly, the method resembles the old technique of felting, normally applied to the manufacture of sheet material from animal hair, natural or synthetic cloth fibers, and wood fiber. In the last instance, tremendous quantities of paper are made by a continuous high-speed felting operation on a moving screen, known as the Fourdrinier process.

A suspension of metal fibers can be treated in the same general manner to produce a porous metal structure having some remarkable properties. The as-formed felt can be compacted by various methods, heated to sinter the fibers at points of contact, and finally impregnated with a corrosion-resistant material.

Such a material might be considered to be a "metal" with corrosion protection "built in," or it might be considered to be a plastic material with metallic reinforcement. In any event, the potentialities of this and other composite materials in engineering should not be overlooked.

Another structural material for machines which has perhaps been overlooked by many designers is solid glass. Because of its brittle nature, it is often excluded from consideration; metals are used instead. When fabrication costs, strength, wear resistance and, of course, corrosion resistance are considered, there are many instances where precision-cast glass parts can serve admirably. A typical application is the use of a large glass bell-like cover for a humidity chamber. Its metal counterpart would be double-walled and expensive to fabricate, less corrosion resistant, and opaque. Even in precision machines, glass bearings can serve admirably where corrosion conditions would make a metal part short-lived.

While the future will undoubtedly bring many new and more potent corrosive agents—already met in nuclear reactors and rocket fuels—ingenuity in combining structural materials promises to meet each challenge. Only when we are firmly established in the new high-vacuum frontier of space will our atmospheric corrosion problems be relieved.

Tips and Techniques

Inking Hard-Surface Papers

Very hard-surface papers, such as the new photographic-type papers, are usually prepared for inking with pounce or similar preparations. If this doesn't seem to work, try erasing the surface to be inked with regular art gum. — RICHARD MARSH, *Lima, O.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, *Machine Design*, Penton Bldg., Cleveland 13, O.

Trends in SLEEVE BEARING

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IN THIS age of expanding mechanical requirements, new bearing developments occur every day. On the other hand, these developments are having little effect on major trends in sleeve bearing materials. The reason is simple: for most applications, standard, high-production sleeve-bearing materials are available.

The principal materials used in sleeve bearings today are the metals or alloys of tin, lead, bronze, copper-lead, aluminum and silver. The difference in properties between a hard bronze and a soft lead-tin alloy is very great; metallic materials are available to satisfy all but the unusual demands. Consequently, no extreme effort is being expended to find a major new bearing material.

New bearing materials or bearing structures are not developed for large-scale use in short periods of time. Early during the last war, the silver aircraft bearing was developed in very few years. With this exception, most major new developments, such as bimetal bearings, overlay bearings, powdered metal and aluminum bearings, have taken over a decade to progress from the experimental stage to substantial production.

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However, for unusual bearing requirements it is well to take a look at the less common materials. For instance, there is a fair demand for high-temperature bearings. But the demand is not sufficiently great to attract research dollars for commercial, mass-production development.

It is difficult to imagine a material that cannot be used as a bearing for a special application. Minerals, natural and synthetic organic materals, leather, wood, rubber, metals, carbon and paper have all been used. Composite shapes, bimetals, and complex oil and solid-lubricant retaining structures have been applied for difficult bearing problems. Many manufacturers have evolved unique designs or utilized uncommon materials.

The Bearing Paradox

Except for extreme applications, a bearing must be hard and soft at the same time. The bearing must be hard to resist wear and deformation. At the same time, it must deform and conform under unfavorable loads. It must also be sufficiently plastic and elastic to accept or engulf small, hard

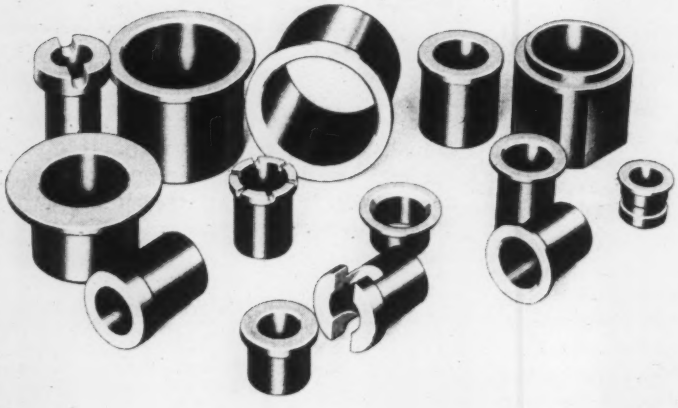


Fig. 1—Bearings made from powder metal, a type of material in which new compositions are finding wider application.

MATERIALS

Few startling changes have occurred recently in sleeve bearing materials. Two metallic materials—powder metals and aluminum—have become firmly established. And the plastics, graphite, and composite bearing structures are growing in importance.

particles. This problem has been solved in many cases by the use of a hard backing and a soft surface layer. Although this method may now be considered as old, it is a continuing trend.

Precision fits and thin bearing surfaces are still new in many industries. The change from heavy-wall to thin-wall bearings requires close-tolerance machining of the housing and shaft. Tolerances must be low enough to permit use of a press or crush fit, but still allow proper shaft clearance after assembly. Thus, the trend to close-tolerance machining and grinding lays the groundwork for utilization of precision bearings.

These practices also make possible the use of thin, soft-metal surface layers. Thin layers carry higher loads, and many designs for thin surface layers have been put into production in the past few years.

Standard Materials—New Developments

Two materials that are finding many new bearing applications are powder metal and aluminum. Graphite and plastics are also being more strongly investigated.

Powder Metals: These metals can be used where other materials are not successful, since the porous metal bearing carries an oil supply within its wall, Fig. 1. In many applications these bearings offer a low-cost method of saving machining on complex shapes.

In recent years, better metal powders, quality process control and larger presses have been put to use. Higher strength iron alloys are replacing the bronzes for lower cost and higher loads in some cases. Also, it is now realized that the porous structure is not necessary in many applications, so that denser bronze alloys are in demand.

Stainless-steel parts are manufactured for high-temperature corrosion-resistant exhaust-manifold butterfly valves. Parts such as shock-absorber pistons are manufactured from copper-iron powders. Multipurpose parts functioning both as gears and bearings are becoming more common.

Aluminum: Although aluminum bearings are not widely used, they are gaining popularity, Fig. 2. Aluminum-tin and aluminum-silicon alloys are performing well for heavy-duty bearing service, such as in connecting-rod and main bearings in automotive and diesel engines.

Test data and service experience have shown that aluminum alloys will carry higher loads than the copper-lead alloys. The bronzes have higher load-carrying capacities than the aluminum alloys, but they do not have the surface properties re-

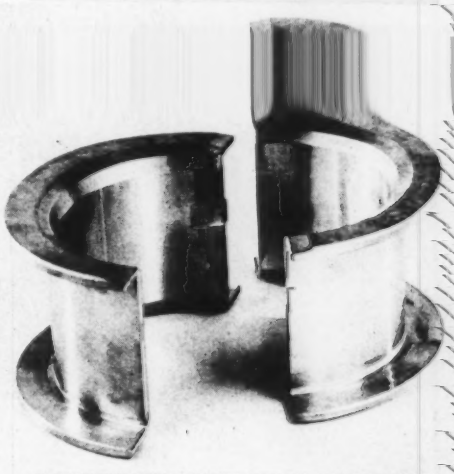


Fig. 2 — Aluminum-lined, steel-backed bearing, a metal combination used increasingly on heavy-duty types of bearings.

quired for the surface speeds encountered in modern engines.

The copper-leads are a common answer for such higher-speed applications. However, the matrix of these alloys is much weaker than the bronzes due to the space occupied by the lead in the alloys. Since the aluminum alloys are relatively low in alloying constituents the aluminum matrix is strong, yet the aluminum matrix is softer than the copper matrix.

Aluminum, thus, is a compromise material able to carry relatively high loads and still maintain the ability to conform and deform under load and temporary distress.

For less demanding applications it is expected that standard alloys, such as 2024, 5052 and 6061, will be found to apply. Cost, low-temperature casting and good machinability are the attractive features of aluminum.

Methods have been developed for bonding aluminum to steel strip, and methods have also been developed for electroplating overlays when required. Thus, aluminum is now being used as solid metal, with steel backs, and with overlays.

Graphite: Solid lubricants have been used in combination with bronze for many years. Plug graphite, pressed into holes in the wall of a bronze bearing, will withstand higher temperatures than the bronze alone will tolerate. Indented bearing stock is filled with a solid graphite-shellac mixture to produce steel-backed, bronze-lined indented bearings for applications such as water pumps, Fig. 3. Solid graphite bearings are successful as furnace bearings for operation at temperatures up to 800 F. It has also been found that solid graphite bearings can be used for low loads where it is desirable to avoid oil.

Plastics: The use of plastics, such as nylon and Teflon, for oil-free bearing applications has increased interest in low-friction solid surfaces. These plastics are used in a great many low-load applications, such as home appliances and light-duty mechanical devices.

An interesting recent English development (Glacier Metal Co. Ltd.) is the use of a thin film of Teflon to take advantage of the dry lubricating properties of this plastic at higher loads. Bronze-lined steel-backed bearing stock is impregnated with Teflon.

The price of Teflon is quite high when used as a solid. Impregnated construction, however, keeps the cost down and yet makes available this inert material with a very low dry coefficient of friction. It is particularly suitable where oil is objectionable, such as for food, textile and processing machinery, or where oil is difficult to retain. However, it will perform well in the presence of a lubricant.

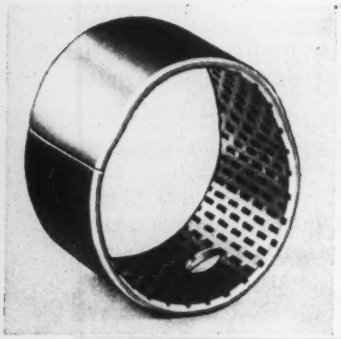


Fig. 3—Indented and graphited bearing, a type used where lubrication by water alone may be necessary.

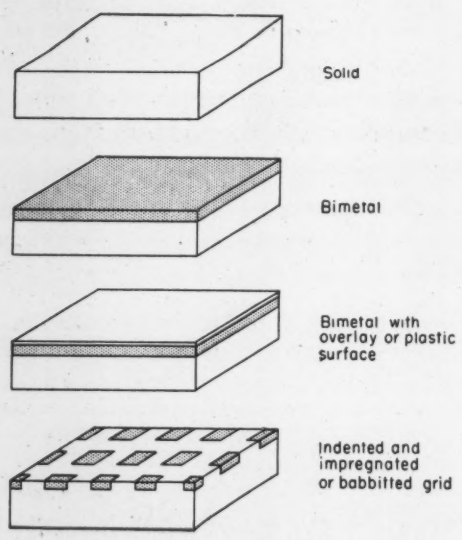


Fig. 4—Sleeve bearing structures. Composite structures are one method of obtaining two or more different material characteristics in the same bearing.

Progress—Slow but Steady

Newer bearing materials gradually replace, but do not eliminate, the older bearing materials. Aluminum will replace some copper-lead and babbitt. Meanwhile copper-lead continues to replace babbitt. Babbitt-lined steel is still replacing poured babitt.

But, even though the trend is away from the babbitts and to the higher strength materials, none of these have the desirable surface properties of the softer babbitts. Electroplated overlays, gridded bearings and plastic-lined bearings offer a softer surface with a high-strength backing. These composite structures, Fig. 4, seem to be the present answer to the problem of obtaining a high-strength, soft-surface bearing.

Continued increase in number of mechanical devices is also increasing bearing requirements for load, speed, temperature, and corrosion resistance. Thus, more types of bearings, rather than less, are likely to be developed. Although there is little indication of change for the major bearing materials, unique and unusual materials and designs will broaden the usage of the less common materials.

PHOTO CREDITS

Johnson Bronze Co. ..... Figs. 1, 2 and 3

Where we stand today in engineering use of

METALS FOR LOW TEMPERATURES

How temperature, stress systems and material properties influence selection of ferrous and nonferrous alloys for low-temperature applications.

By Allan L. Tarr
Consultant in Metallurgy
Alexandria, Va.

THE IMPORTANT material factors in design for low-temperature service appear to be impact resistance (toughness), thermal expansion, thermal conductivity, and tensile and yield strengths.

Tensile strength, yield strength and modulus of elasticity almost invariably increase as temperature decreases. Therefore, in most designs, these properties introduce no problems in low-temperature service. However, design strength should be increased slightly to combat increases in load caused by freezing of parts to the ground and to each other, increase in viscosity of lubricants, loss of ductility of rubber parts, and other related phenomena.

Coefficient of thermal expansion decreases with a decrease in temperature, but thermal conductivity increases. Allowance should be made for differential thermal expansion and thermal conductivity characteristics of materials. Notches produced by thermal and corrosion cracks are serious when temperature is reduced. Large masses of steel sometimes undergo brittle failures because of residual stresses augmented by decreasing temperature. Contraction stress, effect of plasticity, and thermal gradients are all emphasized by reduction of temperature.

The Basic Problem—Toughness

The majority of low-temperature failures are probably associated with insufficient toughness. In some metals, toughness is high at all temperatures and there are no special design problems. Other metals have relatively low impact strength at room temperature and do not become significantly more brittle at lower temperatures (their transition temperature is above room temperature). With such materials, designs which are satisfactory for ordinary temperature should be satisfactory for low temperature.

Materials such as steels (except austenitic steels), zinc-base and titanium-base alloys are usually tough at room temperature, but some of them tend to become brittle at low temperatures. If tensile stress on the part in service is only a small fraction of the yield strength there may be no problem. However if design stresses are at a high level under service loading, the part should

Design Precautions To Avoid Brittle Failures

Do

1. Use metals and alloys suitable for the service.
2. Use metals with Charpy V-notch impact-test values higher than 15 ft lb at the lowest expected service temperature, unless adequate service experience indicates that a lower value is satisfactory.
3. Change sections gradually to avoid reentrant corner stress raisers.
4. Use butt joints in welding instead of lap joints.
5. Join parts of unequal stiffness with a gradual transition.
6. Streamline fillet-weld joints by tested and proved methods.
7. Specify good workmanship, and provide for adequate inspection for stress-raiser types of defects.

Don't

1. Introduce high restraint in localized regions.
2. Have large local variations in ability to deform under applied loads.
3. Weld intermittently for many-cycled stresses.
4. Specify excessive welding.
5. Use eccentric joints in welding.
6. Weld fittings, handles or bosses—or cut openings—at regions of high stress.

—Fatigue Committee
Welding Research Council

be designed using a material whose temperature of transition from tough to brittle behavior is below the lowest service temperature. This is normally −65 F for atmospheric exposure, but much lower for special industrial service.

To obtain an adequately low transition temperature for atmospheric conditions, a test of the part under simulated service conditions should be prescribed at temperatures below −65 F, or a standard impact test should be conducted on the material from which the part is made. In the latter case, the simplest approach is to prescribe an impact test at an arbitrary temperature of −65 F or lower. This rough method, however, sometimes leads to unsafe underdesign or uneconomical overdesign.

A somewhat more refined approach would be to specify a test of the standard impact test specimen at a temperature equivalent to −65 F or lower in the part, using a known strain-rate versus transition-temperature relationship to calculate the proper test temperature.

Because of the statistical nature of fracture, however, it is probably not feasible to design parts

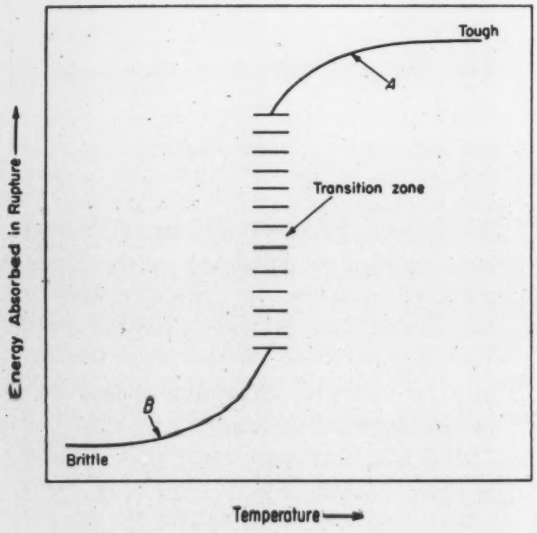


Fig. 1—Ductile-to-brittle transition zone in plain carbon steels.

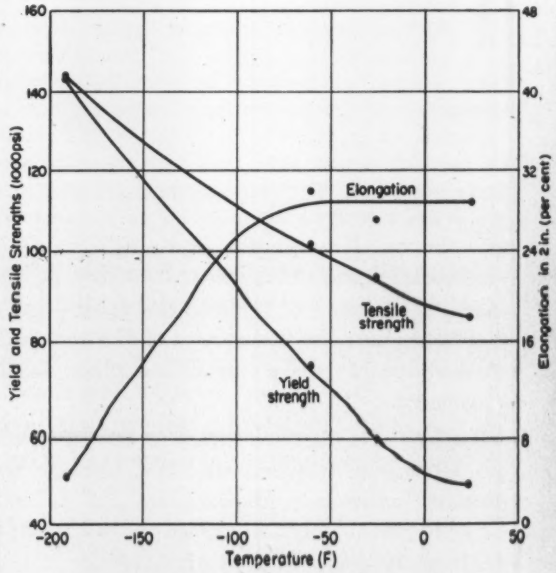


Fig. 2—Variation of tensile properties of normalized SAE 1035 steel with temperature.

from materials that have transition temperatures low enough that the risk of fracture is zero. The designer's problem is to reduce the risk of fracture to the minimum, taking both cost and the consequences of service failure into consideration.

Factors Affecting Metal Failure

The following discussion gives a more detailed analysis of the effect of various factors on low-temperature properties of metals, particularly ferrous-base materials.

Most metals and metallic alloys possess two distinct ranges of fracture characteristics. The ranges are distinguishable by a difference in the energy absorbed by the metallic material during fracture. For example, a ductile material deforms plastically prior to failure, absorbing strain energy during the deformation. A brittle material, on the other hand, fails with little or no prior plastic deformation and with little absorption of strain energy.

Several factors determine the manner in which the metal will fail: (1) operating temperature, (2) strain rate, that is, rate of application of load, (3) nature of the stress system, and (4) material properties.

Operating Temperature: Experimentally it is found that energy absorbed during impact remains fairly constant for a wide range of temperatures, range *A* in Fig. 1. With decreasing temperatures, however, a small range of temperatures (transition temperature range) is encountered in which the energy absorbed prior to failure decreases markedly. At temperatures lower than the transition temperature, a second wide temperature range, *B*, of low energy absorption exists.

Evaluation of low-temperature properties of a metallic material can best be made from its stress-temperature graph, Fig. 2. The relative effects of the previously mentioned factors, plus the characteristics of different base alloy systems, can be evaluated in terms of the relative position of their energy-absorption versus temperature curves.

Rate of Application of Load: Strain rate is an intensifying factor. Increasing the rate of application of load results in a shift of the transition temperature toward higher temperatures. Thus, many materials with relatively inferior impact properties may be employed, even at low temperatures, providing no possibility of impact loading exists. Conversely, static mechanical properties can not be used alone to guide the designer in applications involving low temperatures and impact load.

Nature of the Stress System: Materials containing internal stresses or regions of stress concentration will absorb a smaller amount of externally applied energy prior to failure. The roots of notches, or improperly designed changes in dimension, result in severe stress concentrations of this type, Fig. 3. Biaxial and triaxial stress systems may lead to brittle fracture wherever stress ratios are unfavorable to plastic flow.

Material Properties: Metals with a face-centered cubic crystal structure (copper and nickel-base alloys, austenitic steels, unalloyed aluminum, etc.) maintain relatively high impact resistance over the entire range of normal service temperatures. Materials such as cast iron, magnesium and chromium-

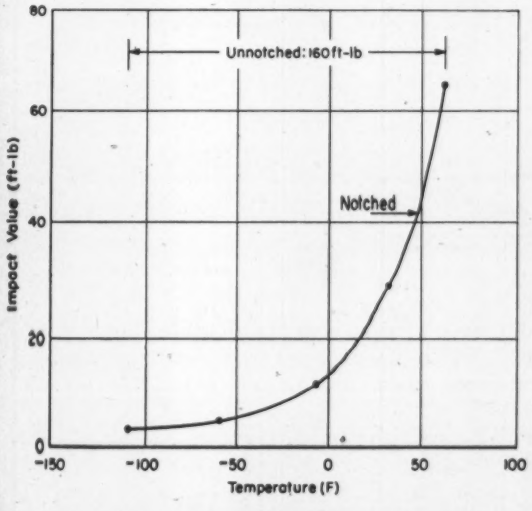


Fig. 3—Effect of stress concentration on impact strength of wrought iron at low temperatures.

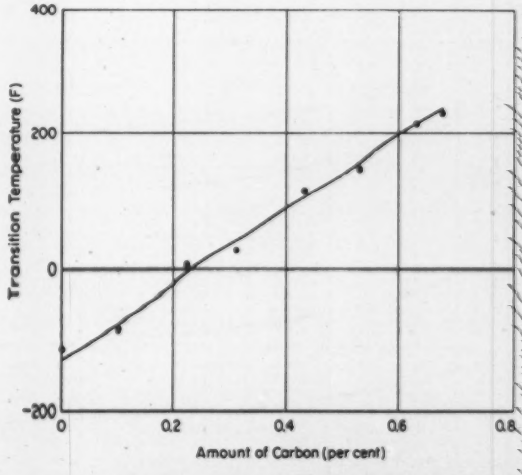


Fig. 4—How carbon concentration affects transition temperatures of normalized steels.

base alloys have relatively low impact values at room temperatures, since their transition temperatures are above room temperature. If designs employing these materials are satisfactory at room temperatures they are usually acceptable at low temperatures.

Materials with a body-centered cubic structure, such as steels (except austenitic), and close-packed hexagonal materials such as zinc-base and titanium-base alloys, usually undergo severe transitions in impact resistance at temperatures below room temperature, Table 1. Designs involving these materials must take this factor into consideration. Proper evaluation of the impact resistance of the

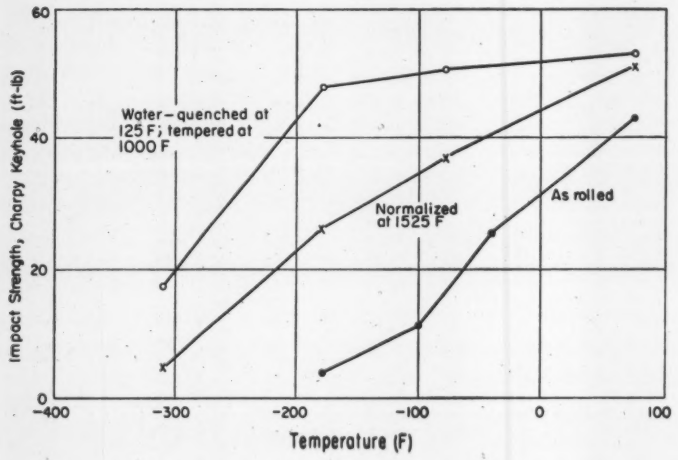


Fig. 5—Effect of heat treatment on low-temperature impact properties of SAE 2315 steel.

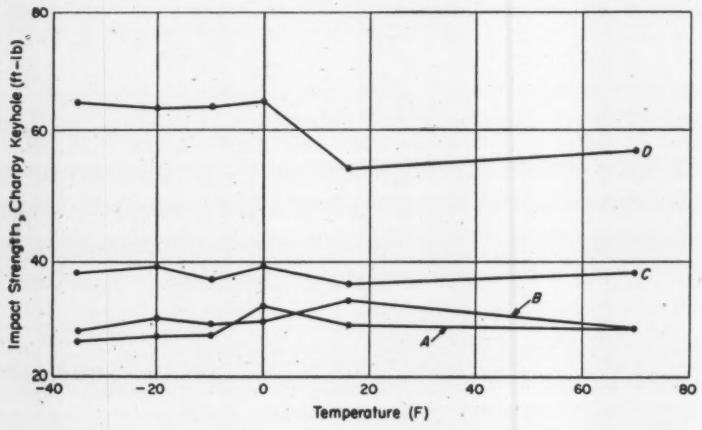


Fig. 6—Variation of low-temperature impact strength with tempering temperature of SAE 2317 steel: *A*—as quenched, *B*—tempered at 440 F, *C*—tempered at 810 F, *D*—tempered at 1150 F.

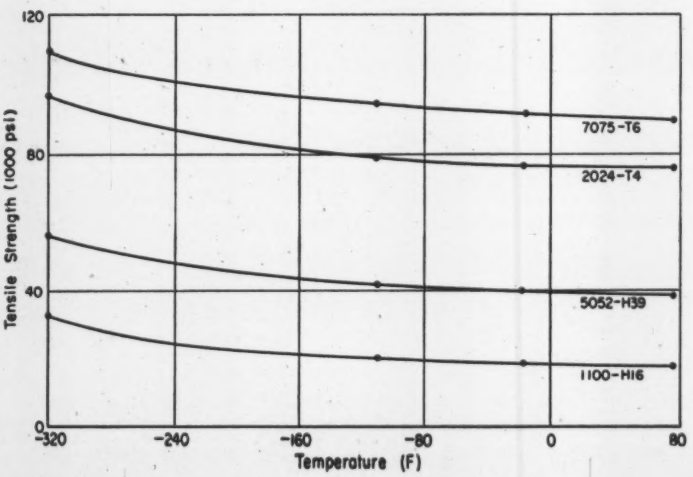


Fig. 7—Temperature versus tensile strength for aluminum alloys.

design must be made through estimates obtained by impact tests under simulated service conditions.

Metal Properties at Low Temperatures

Ferrous Alloys: Increasing carbon content for a given base-composition steel decreases room-temperature impact resistance markedly and shifts the transition-temperture zone to higher temperatures, Fig. 4. High-carbon steels are brittle at room temperature and, therefore, transition temperatures decrease only slightly at lower temperatures.

Impact resistance is not primarily a function of the carbon content, but rather depends to a greater extent on the form and degree of dispersion of carbon and carbide precipitates. It has been definitely established that randomly distributed spheroidized carbide particles, characteristic of fully tempered martensitic microstructures, are the most favorable to low-temperature toughness. The relatively long, parallel platelets of carbide, characteristic of pearlitic microstructures, which are found in hot-rolled steels are the least favorable. Because of their low hardenability, the plain carbon steels are limited to pearlitic microstructures in most of the sizes in which they are applied, and alloy additions are necessary to permit the attainment of the desirable tempered martensitic microstructure.

For applications of increasing severity of service, upgrading of toughness may be accomplished by going from first towards the last in the following series: (1) as-rolled, semikilled carbon steels; (2) as-rolled, semikilled, lower-carbon, higher-manganese steels; (3) as-rolled fully-killed carbon steels; (4) normalized, fully-killed carbon steels; (5) heat-treated (fully quenched and tempered) low-alloy steels; and (6) austenitic steels.

Additions of nickel to a fixed ferrous-base material improve its impact resistance. Nickel, a non-carbide-forming element, is soluble in ferrite. The ferritic steels containing nickel may be heat-treated to improve strength and impact characteristics. The quenched and tempered condition is found to possess the most favorable properties, Figs. 5 and 6.

Addition of greater than 8 to 9 per cent nickel to plain carbon steels results in retainment of the austenitic phase at room temperature and below. These steels, being face-centered cubic in crystal structure and of high alloy content, possess excellent strength and impact characteristics. Combined with sufficient chromium, as in the stainless steels, these materials have excellent low-temperature and corrosion-resistant properties. Their use, however, may be restricted through cost considerations.

Manganese alloy content up to 1.4 to 1.6 per cent increases the impact resistance of low-carbon steels. Manganese contents above this range are detrimental to impact performance. Manganese addition to steels which are normally sensitive to temper embrittlement increases sensitivity of the steel.

Chromium added to steels to improve quenching response also improves impact resistance. Small amounts of molybdenum are usually added with the chromium to offset the slight tendency of chromium to cause temper embrittlement.

The effect of silicon on the impact properties of steels occurs in two ranges. Small amounts of silicon, sufficient only for deoxidation, improve impact properties of the steel; silicon additions greater than that for deoxidation greatly reduce

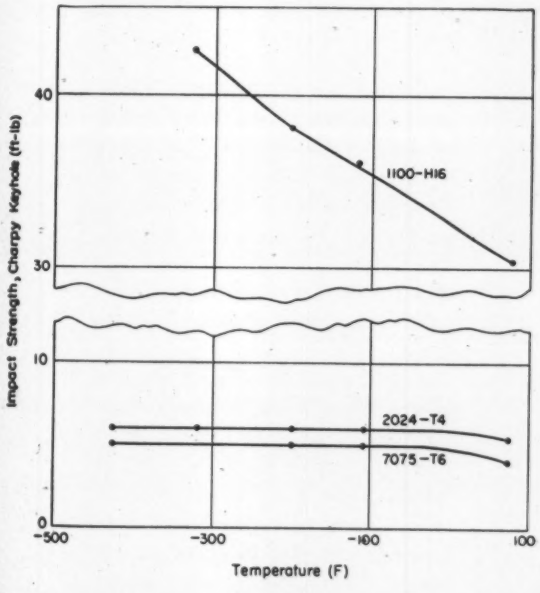


Fig. 8—Impact resistance of aluminum alloys at low temperatures.

Table 1—How Crystal Structure Affects Low-Temperature Properties of Metals

Temperature (F)	Body-Centered Cubic[1] (plain carbon steel)	Face-Centered Cubic[2] (cartridge brass)	Hexagonal Close-Packed[3] (M1 magnesium alloy)
	Impact strength, Charpy V-notch (ft-lb)		
Room	38.3	85	4.0
32	...	86	3.5
0	26.0	...	2.7
− 25	20.0	89.5	..
− 40	3.0	...	2.8
− 75	2.5	...	..
−100	2.3	89	2.8

1. *Low-Temperature Properties of Ferrous Materials*, SAE, New York.
2. Smithells—*Metals Reference Book*, Interscience Publishers, 1949.
3. Publication U5235, Armed Services Technical Information Agency, Page 32.

low-temperature impact properties.

Molybdenum is added to facilitate production of desirable microstructure through heat treatment. Molybdenum is a carbide former similar to chromium.

Sulphur in the form of a distribution of sulphide inclusions has detrimental effects on the tensile as well as impact properties of steels. For improved properties, sulphur must be kept at lowest content. Phosphorus produces a similar result in steels. Although tensile properties increase, ductility and impact resistance drop rapidly with increasing amounts of phosphorus.

The presence of even small amounts of the interstitial elements, nitrogen, oxygen and hydrogen, are detrimental to the impact properties of steels. Larger amounts of nitrogen result in nitride precipitates which adversely affect impact properties of the material.

Addition of small amounts of aluminum to deoxidize steel results in greatly improved low-temperature toughness.

Nonferrous Alloys: Copper and all alpha brasses have face-centered cubic crystal structures. All of these metallic materials possess good low-temperature impact resistance.

Nickel-base alloys such as Monel and Inconel, as well as others, are face-centered cubic and possess excellent impact properties at low temperatures. These materials maintain their impact resistance down to the lowest temperatures investigated.

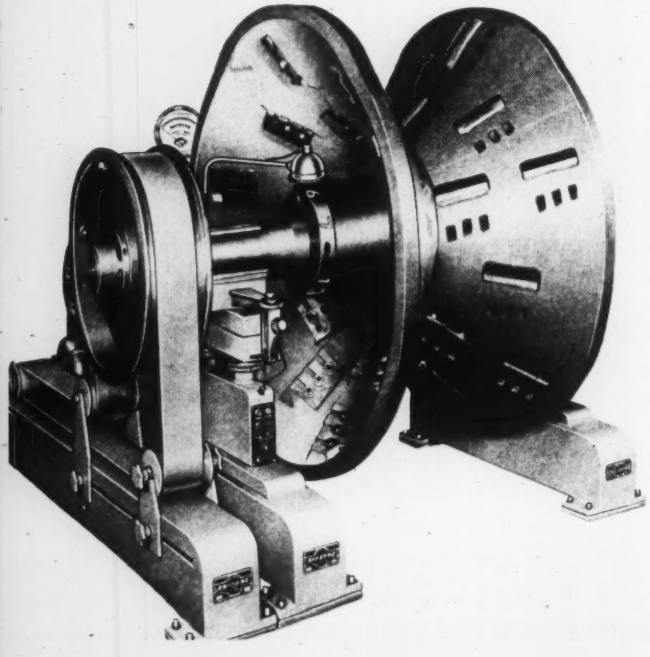
Primary solid solution alloys of both magnesium and zinc possess close-packed hexagonal crystal structures and exhibit poor low-temperature impact properties. For these metals the transition zone is above or slightly below room temperature.

In many respects, aluminum alloys are readily adaptable to low-temperature applications — tensile and yield strengths, hardness, and ductility increase as the temperature is decreased, Fig. 7. There is no evidence of a critical temperature at which solid-solution (face-centered cubic) aluminum alloys become brittle. On the other hand, heat-treatable aluminum alloys do not possess favorable impact characteristics.

Impact values (Charpy) for one nonheat-treatable alloy, 1100-H16, are presented in Fig. 8, together with similar values for two heat-treatable alloys, 2024-T4 and 7075-T6. Charpy values for the high-strength wrought alloys are low at room temperature and are practically unaffected by further decrease in temperature. On the other hand, the Charpy values for alloy 1100-H16 increase slightly from room temperature to −315 F, after which they decrease slightly.

Contemporary Design

Unit Design Increases Balancing Machine Versatility



BALANCING of rotating equipment covering an extremely wide size range is possible with a new balancing machine composed of three separate units. Known as the Mogul, the machine consists of two bearing units and a drive unit. Bearing units can be spaced as the length of the assembly to be balanced dictates. The drive unit may be placed at either end of the assembly or between the bearing units if expedient.

A product of Raydyne Corp., the Mogul incorporates a true seismic unbalance indicator attached to work-supporting mountings which provide over 4 in. of free amplitude travel. Universal V-type bearings are used to eliminate the necessity of making and fitting special bearings for different balancing jobs.

Recent developments in

PACKING AND GASKET MATERIALS

Fluorocarbon plastics and new elastomers set the pace in the search for more effective sealing materials.

By Robert H. Koch

Engineering Services Div.
Engineering Dept.
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THE PROBLEM of sealing joints is becoming more complex. Requirements for heat and cold resistance, chemical resistance, and life are tightening up. As a result, there is a continuing search for more effective and economical sealing materials. The purpose of this article is to take a broad look at some of the more recent packings and gaskets, and some that look promising but are not yet widely used.

PLASTICS—

Fluorocarbons Set the Pace

Use of plastics as packing and gasket materials is well established, but the combinations of properties that become available as research progresses are unlimited, for the industry is still in its infancy.

Much recent attention has been directed at fluorocarbon plastics — polytetrafluoroethylene (Teflon) and monochlorotrifluoroethylene (Kel-F, Fluorothene). These two types of plastic with the jawbreaking names have excellent chemical resistance. Teflon has the additional advantage of a relatively low coefficient of friction, a desirable quality when sealing moving parts. Kel-F and Fluorothene, however, can be molded easily. Both types have excellent resistance to heat within their limiting range, although Teflon's heat-distortion temperature is higher.

For convenience, and following the convention widely adopted in England, polytetrafluoroethylene will be referred to as "PTFE." By analogy (and this is not standard practice), "MCTFE" will denote the monochlorotrifluoroethylene type.

PTFE Felt Impregnated with PTFE Dispersion: One of the newest materials is made by compacting Teflon fiber into sheet form by a special felting technique, and using the dispersion as a saturant to fill voids. Gaskets made from this material have two major advantages over those of solid PTFE plastic: first, a greater compressibility, which permits the gasket to be seated with less bolting pressure and, secondly, a lower rate of "creep" or "cold flow" at increased temperatures.

This material has given over six months' service as a manhole gasket on a glass-lined steel vessel and has eliminated a safety hazard. Teflon envelope gaskets normally used in such service were not acceptable because contamination in the atmosphere would deteriorate the filler material. Load on the gasket would then be relieved, and the gasket would no longer seal, so that flammable process vapors would escape. The excellent mechanical properties of the material are indicated by the fact that the manhole is removed three times during every eight-hour shift.

Another interesting application is the four months' service obtained for nozzle flanges of high-silicon iron handling very corrosive liquids. The best life obtained from a Teflon envelope and

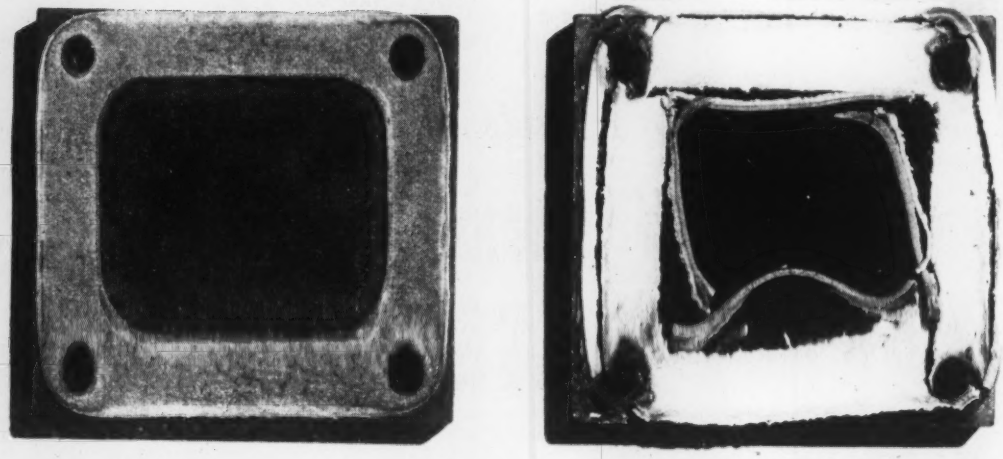


Fig. 1—Resistance to heat distortion of Teflon reinforced with ceramic fiber, left, and plain Teflon, right, tested at 700 F with a flange pressure of 1000 psi. The plain Teflon gasket extruded extensively on all edges and, as a result, the initial gasket load was lost. The reinforced ceramic- fiber Teflon did not extrude and retained approximately 50 per cent of the initial gasket load.

other types was two weeks.

Because of its unusual properties, the impregnated PTFE felt gasket shows promise for use in dynamic applications. Tests are under way for use as O-rings, a seal on a flapper valve, and shaft or rod packing.

Fabric Laminates Impregnated with Fluorocarbon Dispersions: Both PTFE and MCTFE have been successfully used for some time as dispersions for impregnating fabric laminates. Such gaskets give excellent service in chemical applications. Although the basic form of this type of gasket is not new, the modifications to adapt it to a specific application are innumerable.

For example, a packing made from a Teflon-impregnated woven-asbestos cloth was found to be porous to a certain combination of process fluids, and also the asbestos fiber lost its strength rapidly under the high operating temperature. The use of a Monel-wire-inserted cloth and additional heat treatment while compacting the gasket under pressure provided an improved gasket which is giving very satisfactory service.

Filled Fluorocarbon Plastics: Various fillers can be added to the basic fluorocarbon plastics to improve resistance to cold flow, heat distortion or extrusion, Fig. 1. Most of these reinforced materials, however, require heavy compressive loads when used for gasketing because of their hardness. But the improved mechanical characteristics often more than offset this one disadvantage.

A new combination of Teflon and an inert ceramic fiber, for example, possesses a chemical resistivity almost equal to that of the solid plastic. This property, combined with the material's mechanical features, makes it attractive as a gasket in chemical service. Excellent results have been obtained in completely eliminating or minimizing cold flow or extrusion in many gasketing applications.

One example is its use as back-up rings for O-rings in aircraft where rings of the flat, scarf-cut type have run over 50,000 cycles at 500 F and at a line pressure of 3000 psi in diester hydraulic fluid without any appreciable deterioration. Other potential uses presently being evaluated include rotary pump packings, V-ring packings for valve stems and reciprocating rods, and seats and disks for valves.

Other fillers, such as glass, asbestos, copper, graphite and calcium fluoride, have been incorporated to give compositions that are well suited for use as bearings, bushings, mechanical seal faces, and other mechanical elements.

Development of these materials, particularly one composed of Teflon, glass fiber and molybdenum disulfide in the form of V-rings and wedge rings on valve stems and reciprocating rods, is presently underway. Although the results look very encouraging, not enough experience is available at the present time to permit a firm evaluation of the advantages of this material.

Teflon Fiber Packing Impregnated with Teflon Dispersion: Although they cannot be considered as the ideal seal, these braided packings have ex-

cellent chemical and heat resistance, and low-friction characteristics. They are compliant to the follower gland, thereby effecting good sealing at lower tensions under moderate peripheral shaft speeds.

One use has been as a valve-stem packing under severe chemical conditions. Another important application is in pump and agitator packing under process conditions requiring complete freedom from contamination. Because of its low-friction characteristics, Teflon fiber avoids the need for supplementary lubrication (the usual cause for contamination), without shortening life. Conventional packing materials without supplementary lubrication fail quickly.

Kel-F Coated Silicone-Rubber O-Rings: These uniquely constructed rings can be used in many severe chemical applications where the straight Kel-F or Teflon O-rings might prove to be too hard for a proper seal. They have the chemical resistance of the Kel-F coating and yet retain much of the resilience of the silicone-rubber core. In addition to giving excellent service as gaskets, these O-rings are performing very well as shaft sealing elements for mechanical seals.

Machined Teflon Envelope Gaskets: PTFE envelope gaskets have conventionally been available as lathe-cut elements, Fig. 2*b*. A new form, in which the ID is milled square, Fig. 2*a*, is proving to be far superior to the old V-type envelope for use with glass and porcelain equipment. Channel construction of the machined envelope permits full contact with the ID of pipe flanges and also keeps the gasket from extending inside the ID of the pipe to impede flow.

Bonded-Teflon Fabricated Gaskets: In this newest development, the surface of the Teflon is changed chemically by a sodium treatment so that the coefficient of friction is increased and adhesion properties are improved. Therefore, it is now possible to obtain a bond between two pieces of Teflon or between Teflon and metal. This bond is limited in strength and chemical resistance only by the properties of the adhesive itself.

Use of bonded Teflon constructions as packing or gasket materials is unexplored, but the extent that they might be employed depends only on the ingenuity of the packing manufacturer and the design or maintenance engineer. For example, it might be possible to use bonded Teflon in fabricating totally enclosed envelope gaskets or in bonding preformed gaskets to metallic surfaces.

ELASTOMERS—
New Types and Compounds

The last decade has seen a large increase in the number of new synthetic rubbers as well as marked improvements in the properties of well-established elastomers. However, in most instances, there is a long time interval between the

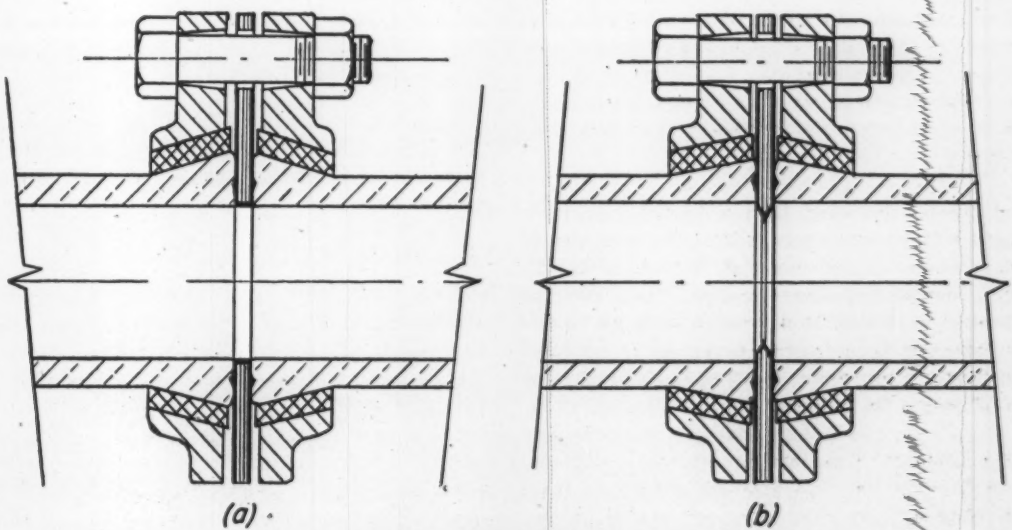


Fig. 2—Machined Teflon envelope gasket, *a*, fits flush with the ID of the pipe. By contrast with previous V-type, *b*, this construction provides minimum impedance to flow and eliminates the possibility of pockets being formed.

announcement of a new elastomeric material and its commercial availability in the form of packing or gaskets. Much laboratory and field test work must be done, and compounding techniques developed, before it can be put to work in suitable functional applications. Therefore, some of the following are a look toward the future.

Hypalon Chlorosulfonated Polyethylene: This new elastomer has demonstrated excellent gasket properties, although it has been more widely publicized for use in acid hose and conveyor belts for handling hot materials. Its outstanding property is its resistance to all kinds of oxidizing conditions. It is immune to ozone, has exceptional resistance to sunlight and weather, to temperatures in the range of 250 to 350 F, and to strong oxidizing chemicals. This acid resistance makes it suitable for chemical applications where a compressible gasket material must be employed. Because of its complete resistance to ozone, Hypalon has replaced plastic gaskets on large industrial ozone generators. Other elastomers would crack and disintegrate in minutes when exposed to an atmosphere containing 2 to 4 per cent ozone.

Kel-F Fluorocarbon Elastomer: This is one of the most promising of the fluorinated elastomers developed mainly for military purposes. It has the unusual combination of good elastomeric properties, chemical resistance, and thermal stability. It is serviceable over a temperature range of −15 to 400 F and is essentially unaffected by white or red fuming nitric acid and other strong oxidizing mineral acids, hydrocarbon fuels and lubricants, alkalies, or aliphatic solvents. As more Kel-F elastomer becomes available for commercial use, it will undoubtedly enjoy wide application for gaskets in severe chemical service at elevated temperatures.

Polyacrylic Rubbers: Several new polyacrylic rubbers with unusual properties have been developed. One specialized material, Vyram or N5400 acrylate elastomer, was developed to provide a rubber-like seal that would resist both hydrocarbon and ester type hydraulic media. In addition to exhibiting minimum swelling and extraction after exposure to various types of either of these fluids, it shows excellent resistance to many hydrocarbon solvents, transformer oils, and alcohols. Available only in development quantities, this elastomer may demonstrate its superiority in certain services after more extensive field tests.

Poly-FBA, a fluorinated polyacrylic elastomer developed to meet the military need for rubbery materials, should be suited for many uses in chemical and hydraulic equipment. It is capable of functioning over a temperature range from 0 to 400 F, and is highly resistant to various liquid fuels, lubricants, solvents, and ozone. Although it is highly resistant to the chemical action of fuming nitric acid, it is quite permeable to it.

Silicone Rubber: Although this semi-inorganic rubber is not new, its chemical structure is such that compounds can be produced in a number of physical forms with differing characteristics. Among the latest developments are:

1. A flame-resistant material for use as seals in contact with flammable fluids.
2. A combination of silicone and Teflon which retains the excellent thermal properties of the rubber, but with greater tear strength and improved oil resistance.
3. Various other compounds which exhibit specific properties such as low-temperature resistance to −120 F, high-temperature stability to 600 F, or low compression set of 10 to 20 per cent.

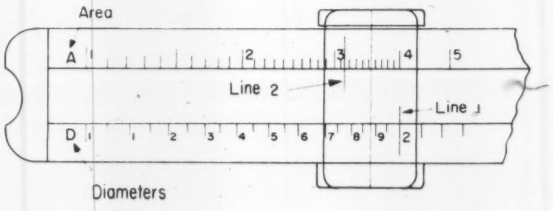
Urethane Rubber: This new family of elastomeric materials is made by reacting a di-isocyanate with a high molecular-weight glycol. These rubbers possess excellent physical properties, such as high strength, high resistance to tearing, and outstanding abrasion resistance compared to other elastomers. In addition, they are oil and solvent-resistant and are slow aging. Exactly where they will fit in the packing and gasket picture is not yet known, but certainly a material possessing such a combination of properties can be used to good advantage.

Tips and Techniques

Circle Areas on Slide Rules

CIRCLE areas (diameter known) or circle diameters (area known) can be read quickly on a slide rule by scribing two special lines on the indicator slide.

Set the hairline of the indicator slide directly over 1.88 of the *D* scale and scribe a thin line over 2.0 on the *D* scale and over 3.1416 (π) on the *A* scale.



If the *D*-scale mark (line 1) is now set on any specified diameter, the *A*-scale mark (line 2) will show the area of the circle, and vice versa. — JAMES A. CONDON, *Maxon Premix Burner Co., Muncie, Ind.*

SPRING ALLOYS

What metals to select to meet present-day demands for long life, corrosion resistance and accuracy in springs.

- **High-carbon steels**
- **Alloy spring steels**
- **Stainless steels**
- **Spring brass and bronze**
- **Special nickel alloys**

By M. Gerard Fangemann

General Manager
Spring Div.
John Chatillon & Sons
New York

DURING the past few years, industry has become cognizant that springs are, in many instruments and controls, the real heart of the unit. Since space allowances are becoming smaller and smaller, the manufacturer of accurate devices and instruments has to expect more performance from the usual spring. Greater accuracy in spring rate, lower straight-line error, and smaller hysteresis and drift error are all expected. In many cases, along with these requirements, constant strength with temperature changes is also needed, Fig. 1. Lately, even another factor has been added—long life at high stresses, coupled with good corrosion resistance.

Today, the design engineer obviously has a lot more to worry about than economy in the choice of spring materials, particularly if his choice must withstand all these conditions. He must be familiar with the usual spring materials—and they are included briefly in this presentation—but he should also be familiar with some of the newer materials. Table 1.

Spring materials can be classed into three

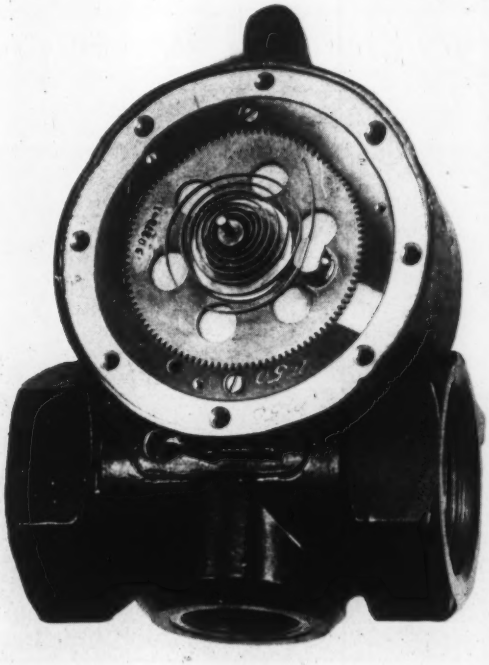


Fig. 1—Temperature-compensated spring material, used in a Bendix fuel flow meter to obtain constant strength with variation in temperature. The spiral Iso Elastic spring must also maintain hysteresis error below 0.3 per cent of total rotation.

Table 1—Properties of Spring Materials

Material	Modulus of Elasticity (million psi)	Modulus of Rigidity (million psi)	Temperature Coefficient—Mod. of Elast. (per deg C)	Temperature Coefficient—Mod. of Rigid. (per deg C)	Tensile Strength (1000 psi)	Max Torsion Working Stress (1000 psi)	Max Bending Working Stress (1000 psi)	Stress-Relieving Temperature (F)	Linear Coeff. of Expansion (per deg F)	Rockwell Hardness	Density (lb/cu in.)
Hard drawn MB steel (SAE 1065)	30	11.5	-312×10^{-6}	.....	150–300	75—130	100–200	500	.....	Varies with cold working	0.284
Oil tempered HB steel (SAE 1080)	30	11.5	-312×10^{-6}	-250×10^{-6}	155–300	80—130	120–250	500	.....	C42–C46	0.284
Music wire (SAE 1085)	30	11.5–12	-312×10^{-6}	-260×10^{-6}	250–500	90—180	150–350	470	6.4×10^{-6}	C45	0.284
Chrome-vanadium steel (SAE 6150)	30	11.5	-263×10^{-6}	-260×10^{-6}	200–250	100—130	180–230	Varies	6.4×10^{-6}	C42–C48	0.284
Chrome-silicon steel (SAE 9254)	29	11.5	.....	.....	235–300	115—150	190–240	Varies	.....	C48	....
Spring brass (SAE 80)	15	5.5	-359×10^{-6}	-400×10^{-6}	100–130	30—60	40–60	500	11.2×10^{-6}	B90	0.309
Phosphor bronze (SAE 5)	15	6.25	$-360-40 \times 10^{-6}$	-400×10^{-6}	100–150	50—85	60–110	500	9.9×10^{-6}	B90–B100	0.320
Beryllium copper	16–18.5	6–7.5	-350×10^{-6}	-350×10^{-6}	160–200	65—95	100–150	600*	9.2×10^{-6}	C35–C42	0.297
Stainless steel, Type 302 (SAE 30915)	28	10	-360×10^{-6}	-400×10^{-6}	160–330	45—140	60–260	600	9.61×10^{-6}	C35–C45	0.290
Stainless steel, Type 304 (SAE 30905)	28	10	.....	.....	160–330	45—140	60–260	600	9.6×10^{-6}	C42–C47	0.286
Stainless steel, Type 316 (SAE 30505)	28	10	.....	.....	140–275	40—120	55–220	600	8.9×10^{-6}	C42–C47	0.288
17-7 Stainless steel	29.5	11	.....	.....	269–320	134—160	195–225	900*	6.1–6.6 $\times 10^{-6}$	C48	0.277
Monel	23–26	9–9.5	.....	.....	135–165	50—63	88–107	575*	$6.1–9 \times 10^{-6}$	.....	0.319
K-Monel	23–26	9–9.5	.....	.....	160–180	60—70	110–120	1000*	6.3–8.6 $\times 10^{-6}$	.....	0.305
Inconel	31	11	.....	.....	140–175	55—80	110–135	Varies	6.4×10^{-6}	C30–C40	0.307
Inconel X	31	11	.....	.....	140–175	55—80	110–135	Varies	6.4×10^{-6}	C30–C40	0.307
Iso Elastic	26	9–2	$-36-+18 \times 10^{-6}$	.....	170	40—60	90–100	750	4×10^{-6}	C30–C35	0.292
Ni Span C	24–27.5	10	$-18-+18 \times 10^{-6}$	.....	90–200	60	15–110	1100–1350*	4.5×10^{-6}	B70–C44	....
Cobenium	29.5	11	.....	.....	375	125	250	750	12.7×10^{-6}	C58	0.300

*Hardening only.

groups: ferrous materials, nonferrous materials, and special alloys. These will be discussed in sequence.

Ferrous Spring Materials

High-carbon spring steels, Fig. 2, play a very important part in industry today, since a lot can be expected from these steels, and they are produced at relatively low cost. The cheapest grade is hard-drawn MB steel (SAE 1065), used for general-purpose applications where cost differences play a major part. This material is best used for low-stress applications where loads are usually low enough not even to be specified on the print.

For more accurate requirements, oil-tempered HB steel (SAE 1080) is usually preferred. This steel is similar to music wire in carbon content and, of course, is more economical. The high carbon content affords better service in high-stress applications than hard-drawn material, but life expectancy is not nearly as great as that expected from music wire.

Music wire (SAE 1085) is the most popular of all spring materials and has the highest tensile properties, under repeated loading, of all steel

Fig. 2—Oil-tempered steel springs, designed for medium stresses to hold hysteresis and drift errors to a minimum. In the Chatillon scale mechanism, repetition of readings, and a good straight-line relationship between load and deflection, are important.

spring materials. It can be used at temperatures approximating 250 F with good success and is easily plated to meet the usual salt spray test. Life expectancy is excellent, which is the one main reason it has become so popular in recent years.

Included with ferrous steels is a group of materials that have to be classified as alloy spring steels. These special steels have been developed to carry on where music wire ceases to be acceptable. Alloy materials can withstand higher stresses at higher and lower temperatures than the previously mentioned high-carbon spring steels. More important, they have a longer life cycle and have better immunity to shock and impact loads.

The most popular alloy steel is "old reliable" chrome-vanadium steel (SAE 6150), which has been used for years for high-stress applications and where long fatigue life is a necessity, Fig. 3. It is used extensively for valve springs, particularly in aircraft.

This alloy is being superseded gradually by chrome-silicon alloy steel (SAE 9254), which is rapidly finding a useful place in high-stress applications. It has good endurance and can also be used to temperatures of about 500 F. This material is competitive with another new material, chrome-moly-vanadium alloy. This alloy has about the same resistance to shock and equally good life. In addition it can withstand temperatures approximating 800 F.

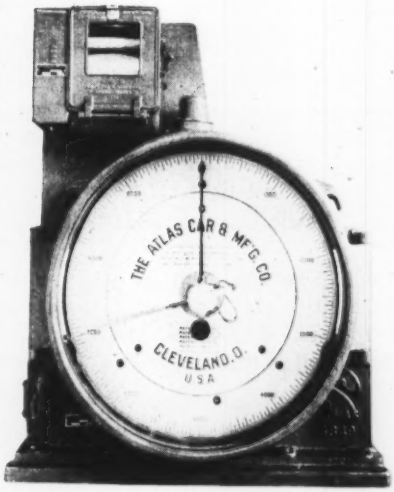
Nonferrous Alloys

Main nonferrous alloys are copper-base materials, which will always be in use where good conductivity is a primary requirement. This property, coupled with good resistance to corrosion, make these spring materials ideal for many electrical applications.

Spring brass (SAE 80) is the least expensive and has probably the highest electrical conductivity of the nonferrous alloys. It has low tensile strength, however, and springs have to be designed at extremely low stresses.

A better choice for springs operating at higher stresses because of space limitations would be phosphor bronze (SAE 81)—a popular alloy for many years. It can withstand at least 50 per cent higher stresses than brass and can be used to approximately 200 F.

An even better alloy is beryllium copper. This is a hardenable alloy that can withstand even higher stresses and still be capable of good conductivity and good corrosion resistance. Unfortunately, it is frequently necessary to jig parts



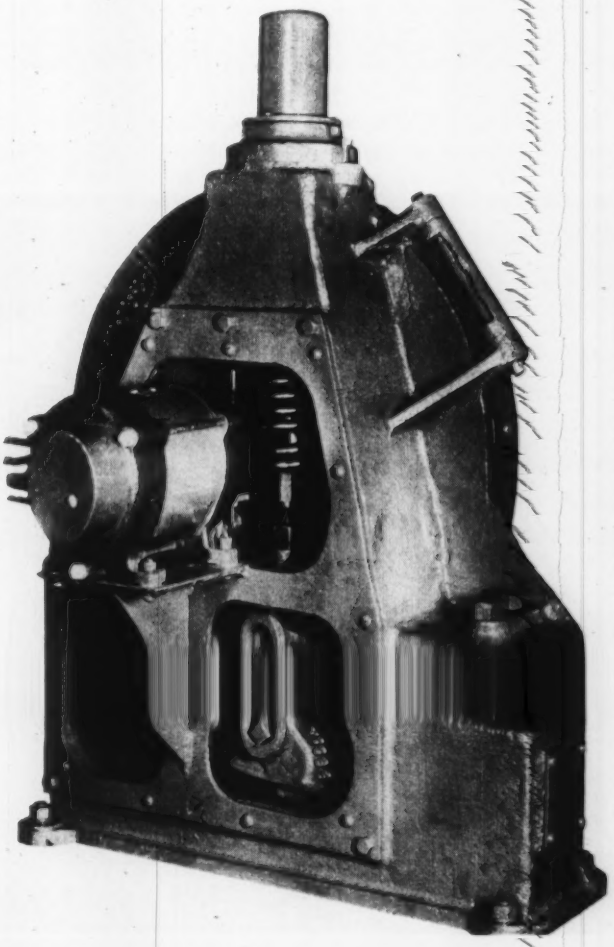


Fig. 3 — Atlas weighing mechanism, which uses chrome - vanadium steel springs operating at extremely high stresses. Springs have to be resistant to shock and impact loads, with long life.

being heat-treated to hold physical dimensions, thus adding to the extra cost of the material itself.

Special Spring Alloys

One group of alloys that has been used increasingly is the stainless steel group. Industry is constantly requiring more corrosion resistance for springs. Various forms of stainless steels are proving to be the ideal answer to many problems.

The most popular stainless alloy is Type 302 or 18-8 alloy (SAE 30915). It has the highest tensile strength of the series and has uniform characteristics from melt to melt. It is not hardenable by heat-treatment, is slightly magnetic, and can be used to approximately 500 F. A satisfactory substitute for this alloy is Type 304 (SAE 30905) when stresses are not considered high. Type 316 (SAE 30805) is similar to Type 302 but has even better corrosion resistance. Operating stresses, however, have to be lower.

When good corrosion properties are required, and operating stresses are necessarily high, a relatively new material may be found worth-while—17-7PH stainless. This alloy contains approximately 1 per cent chromium and 7 per cent nickel as well as titanium and aluminum. It has a tensile strength approaching that of music wire, obtained by heat treatment. It lends itself well to production of formed parts designed at high stresses.

Monel—a nickel-base alloy—has excellent resistance to salt water corrosion, and high magnetic "transparency." It derives its spring properties from cold reduction and is not hardenable. Consequently, low working stresses must be used. Monel has been used successfully at temperatures to 450 F. A variation of this alloy is K-Monel, a precipitation-hardened alloy which can be formed prior to heat treating and used at higher working stresses.

Inconel, another popular nickel alloy, is used primarily at temperatures to 700 F. This material, like Monel, is not heat-treatable, but it does have a higher tensile strength. As a result, it is adaptable for valve springs and other high-temperature applications. Its mate, Inconel X, is made heat-treatable by addition of titanium, columbium and aluminum. Consequently, coiling or forming operations are easier, but there is the extra expense of long heat treatment. This alloy is finding favor for valve springs at service temperatures to 1050 F.

Another group of nickel alloys are noted for constant strength with great variation in temperature. They are classified as constant-modulus alloys, since their modulus of elasticity remains practically constant with temperature. These materials are used only for precise requirements where minute errors would be magnified and troublesome. The various alloys are all resistant to corrosion and can all be considered poor electrical conductors. For convenience, the three main types are described.

The original alloy, Elinvar, derives its spring properties by cold working. However, working stresses have to be kept at low levels. A later modification, called Iso Elastic, also receives its spring properties by cold working, but stress limits can be increased considerably.

In addition to its constant modulus, Fig. 4, Iso Elastic has extremely low hysteresis and drift error. Consequently it has become very popular in precision instruments. The trend today is for greater accuracy of calibration along with almost perfect straight-line relation between load and deflection. Iso Elastic can meet this requirement easily.

Two additional factors help account for Iso Elastic's popularity: (1) lower cost than many materials with similar properties, and (2) greater uniformity from melt to melt.

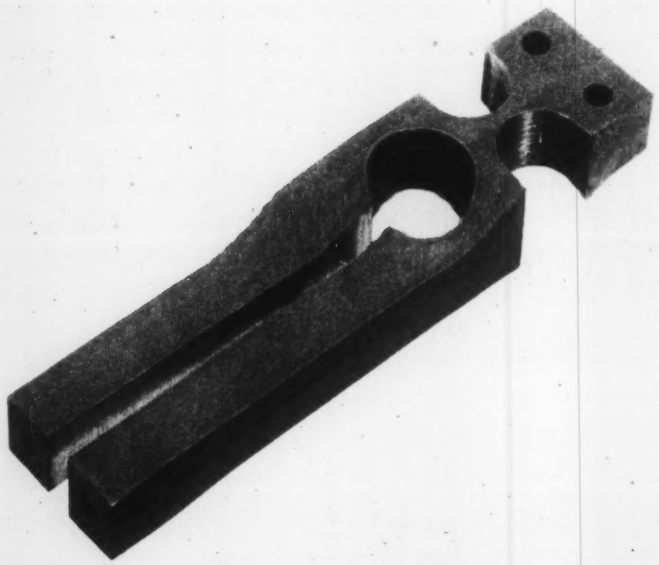


Fig. 4—Tuning fork for Navy gun director, made of Iso Elastic, a temperature-compensated spring material. The unit is calibrated for a 400-cycle frequency, which must be maintained over a wide temperature range.

Sometimes, however, it is necessary to form springs in the soft state and then harden them to obtain spring properties. When this is needed, another constant-modulus alloy can be used, Ni Span C. This material, also one of the nickel alloys, contains nickel, iron, chromium and titanium. It has properties similar to Iso Elastic after hardening. If processing is accurate, hysteresis and drift errors should be quite low, making Ni Span C excellent for precision instrument applications. Both alloys can be used safely for the usual aircraft temperature variation range of −50 to +150 F. However, Iso Elastic has been successfully applied to 550 F.

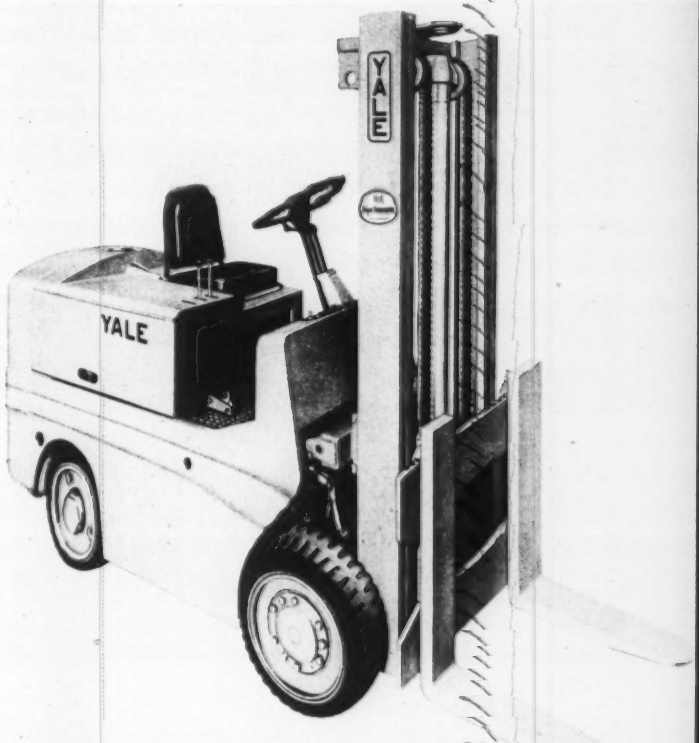
One requirement which has become more frequent during the past year is long life in springs that must operate at extremely high stresses. A material that has proved many times to be outstanding is an alloy called Cobenium. This is a nickel-base alloy also having iron, chromium and cobalt in its composition. It was formerly known as Elgiloy. Its modulus of elasticity is about the same as music wire, and its ultimate strength is usually around 375,000 psi. A lot depends, however, on the procedure used in manufacture in determining the success of the material for spring applications.

This alloy has solved several serious problems. However, the special variation in processing is actually most important in gaining success. One specific example is an Eastern firm that ran into serious difficulty with a limited-space spring required to meet a 25,000-cycle minimum life test. A spring of Cobenium, with a special deviation from normal processing, was capable of not only meeting the 25,000-cycle life test, but of handling a minimum of 75,000 cycles and a maximum thus far of 120,000 cycles.

Contemporary Design

Gas-Powered Lift Trucks Designed for Hazardous Locations

TOTALLY-ENCLOSED generator and starting motor, shielded safety fuel fill cap, protected gas tank, covered battery terminals and rubber boots over all electrical terminals are some of the safety features incorporated in a new line of lift trucks. This is claimed to be the first line of gas-powered lift trucks approved for use in hazardous locations. Other safety features of these lift trucks manufactured by Yale & Towne Mfg. Co. are a spark-arresting muffler, flame-arresting air cleaner, nonsiphoning suction-fed fuel system and a generator and battery cutout switch to break the electrical circuit in an emergency. The trucks are available in capacities from 3000 to 10,000 lb.



MATERIALS FOR

A broad-scale summary of recent materials, coatings and processes developed for low friction and wear resistance.

ENGINEERING descriptions of bearing designs frequently ignore the limitations due to wear. This is natural because wear is often not regarded as one of the limiting parameters. Hydrodynamic bearings are supposed to have infinite wear life. This supposition is either a luxury where time is traded for money, or an ignorance factor which reflects general lack of knowledge about wear. Wear increasingly is a subject of concern in machine design. This concern also motivates a growing number of scientists in the field.

Wear resistant materials should not call to mind tungsten carbide or high-speed steel without some picture of what to expect from alternate materials, so that the most economical and sound selection may be assured. Thus, this article refers to a wide selection of the newer wear-resistant materials to present a proper perspective. Materials reviewed are of two types: (1) bearing materials, used because of their low-friction characteristics, and (2) hard materials, resistant to abrasive type wear.

Aluminum

Aluminum once was regarded as a poor bearing metal, because the metallurgical structure of aluminum does not fit the classical picture of what a bearing alloy should look like, and because aluminum is soft and prone to scoring and galling. Despite this dreary outlook, current research shows that aluminum alloys will do an excellent job where the application is suited.

Many aluminum alloys do have the classical bearing structure of a soft phase distributed in a harder matrix, and these are among those that are being adapted to bearing applications. An alloy of 70 Al, 30 Sn, for example, has improved fatigue resistance over babbitt at the operating temperature of diesel engines and is promising for use in modern high-pressure diesel engines where loads of 3500 psi are encountered.

Load capacities to 5000 psi are reported for aluminum bearings. The problem of bonding to a strong back has apparently been worked out, and corrosion is less severe than with lead babbitts. More resistance to metal-to-metal contact at higher temperatures and increased fatigue resistance for aluminum is reported, compared to copper-lead and babbitt.

Titanium

Unlike aluminum, titanium has not been used for bearing surfaces, although it would be unwise to predict that this is impossible in these changing times. However, titanium is so useful in many ways, and so objectionable because of its galling and seizing tendencies, that progress to make up for this lack is of wide general interest.

Development of a ductile chrome plating process for titanium and aluminum in the fall of 1955 made big news. The Baylig Process patent has not been issued, and details are not available. Samples indicate that a good bond has been produced, making possible a new range of applications. Ductility of the coating is reported to be excellent, indicating that the hydrogen content is low and that the chromium structure is a favorable one. It cannot be assumed that the wear resistance and coefficient of friction of the chromium deposit are the same as conventional hard chrome-plated surfaces, however. Comparative wear and friction coefficient tests would be valuable on this chrome plate.

Molybdenum has been deposited on titanium to make a second method of coating with improved bearing qualities.

Titanium is finding its way into aircraft as fasteners despite the view held earlier that its seizing tendency would limit such applications. Considerable work has gone into a search for lubricants for titanium to reduce the high coeffi-

WEAR RESISTANCE

By Verne Pulsifer
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Chicago

cient of friction. This high friction is due to transfer of titanium to the mating metal surface, with the result that wear and friction characteristics are poor, like those of titanium rubbing on itself. Machining of titanium is also more troublesome than that of many other materials.

Ceramics

Recently, metal oxides and other combinations of metals with the interstitial elements have received much attention because of their unusual performance as cutting tools. Forms now being produced have a dense structure, with thermal shock resistance, high modulus of elasticity, and unusually high hot hardness. Metal oxide cutting tools, principally aluminum oxide but sometimes others, seemingly can cut steel faster, smoother, and with longer life than tungsten carbide.

Boron nitride is a soft ceramic with an unusual combination of properties, including corrosion and oxidation resistance, high dielectric properties, and high thermal conductivity. It is known as "white graphite" because of its excellent machinability. Like graphite, it may have great value in special low-pressure applications, although its availability is now limited.

A new field that is rapidly developing is the field of ceramic coatings. The most wear-resistant of these is believed to be applied by the Poorman process (Linde Air Products Co.). This process for ceramics, as well as other coating methods developed by Norton Co. and Armour Research Foundation, is promising for a number of wear-resistance applications combined with high temperatures.

Carbides

Steady progress continues in the use of carbides for use in all types of tough wear and abrasion-resistant jobs. The new Flame Plating process for application of tungsten carbide and other coatings to a host of materials is an excellent example of the diversified growth.

It is better understood today that carbide failures by fracture can be traced to impact, and that successful application of carbide parts can be achieved only if the carbide is mounted or fastened free from chatter and play. Other important requirements are proper brazing and fitting techniques.

Powder Metals

The range of material combinations and properties developed with powder-metal techniques makes it impossible to generalize regarding wear resistance. Requirements for manufacture of metal powders are often as severe as for cermets and ceramics, except for sintering temperatures. Each material has its special characteristics, and mechanical properties for exacting applications cannot be held, say, if atmospheric contamination of a fine, reactive metal powder occurs. Many of the brass and iron sintered bearings with graphite, oil and plastic impregnation have become standard materials for bearings.

An interesting method of "repairing" bearings is use of powdered metals suspended in a lubricant. This product, composed of finely powdered copper and lead, either dry or suspended in oil, will have utility where bearing access or other circumstances prevent normal maintenance of scored journals and bearing faces.

Special Wear-Resistant Materials

A number of special wear-resistant materials must be included in any survey of the subject. Recent work with some of these classes of materials is reported.

Graphite and carbon brushes are familiar for wear-resistant electrical contacts. These are avail-

able in many special grades. Like many other materials, graphite and carbon are becoming known as bearing materials when they are properly supported. Failures have been reported in graphite bearings at high altitudes, but the outlook is for properly prepared graphite to come back stronger than ever.

Graphite has low friction qualities because of its adsorbed film of water, which is destroyed at low pressures. Other adsorbed films have been substituted which are not lost as easily. Such films are provided by certain hydrocarbons whose film adhesion depends upon the structure of the adsorbed molecules.

Sleeve-bearing alloys are well-known as low-friction materials. They can be classified generally into six types: babbitt, copper-lead, leaded bronze, bronze, silver, and aluminum. Steel-backed copper alloys and silver alloys, along with many other types, are enjoying wide use in automobiles and aircraft. One of the chief advantages of alloys in this class of applications is resistance to seizure under adverse circumstances, such as loss of lubrication. The modern bearings in automobiles and aircraft are an engineering marvel not generally appreciated.

Load capacity of some of these materials is relatively low, but this is compensated for by other advantages such as long life, cool running at high speeds, and easy replacement. Load capacity based on wear-resistance in electric motors has been reported as: 50 psi for sintered bronze and babbitt on bronze; 100 psi for babbitt on steel; 150 psi for copper-lead on steel; and 200 psi for bronze.

The high cost of die sinking has caused re-examination of nonferrous alloys for dies, particularly for use in relatively short runs where wear resistance can be somewhat less than for steel dies. Aluminum bronze is one material being used for press tools.

There is not much new to report on cast iron, white irons, and other basic iron-carbide (cementite) materials. However, these still constitute one of the most useful classes of low-cost wear-resistant materials. They are often used against steel and other softer materials for low-friction, long-life applications.

As indicated previously, plastics are sometimes used to impregnate powder-metal bearings, with excellent results. Teflon-impregnated compacts have been found excellent in severe high-temperature water service. Plastics are also used without the support of sintered metals for low-requirement applications, such as in refrigerators, where functional operations prevent the use of lubricants and require corrosion resistance. Many plastics do not offer low friction coefficients. Polytetrafluorethylene (Teflon) does have a low friction coefficient of 0.05 to 0.1 compared to 0.3 to 0.8 for most other plastics.

Wear-Resistant Steels

Some reports have confirmed the cleanliness that can be obtained by vacuum melting of SAE 52100 ball-bearing steel and tool steel. Test results have shown life increases of 100 to 700 per cent due to the cleaner structure. Early fatigue failures that begin at inclusions evidently are eliminated in the cleaner steels. Vacuum-melted steels will ultimately require revision of a number of specifications to take advantage of their improved properties.

Ball and roller-bearing steels are still popularly made from high-carbon, high-chromium steels such as SAE 52100, or sometimes from medium-carbon steels such as SAE 4140, 1065, or 8660. Cleanliness of these steels is a large factor in trouble-free long life.

Ingenuity has been exercised to enlarge even further the already wide versatility of tool steels. Machinability of certain tool steels has been markedly improved by the addition of lead. Graphitic grades of oil-hardening tool steels have been developed to reduce the coefficient of friction in service. Lower friction proves to be the only path to reduced tool damage for high-pressure and high-temperature service. Both of these improvements are important ones, and they no doubt will be expanded to other grades of tool steels where it is technically and economically feasible.

Surface Hardening of Steel

Surface hardening includes improvement of wear resistance by (1) surface diffusion, or (2) transformation of surface regions. Carbon and nitrogen are two elements used in important surface-hardening processes. Carburizing, nitriding, carbonitriding, and cyaniding for steels depend upon these elements for surface hardening. Nitride-forming elements like aluminum and vanadium should be present in the steels to derive benefit from nitrogen diffusion.

Nitriding has the advantage over carburizing in the high hardness that can be achieved—good for service temperatures to 1100 F. The low treatment temperature also reduces distortion. The white nitride layer should be removed by grinding. The atmospheres used and the depth of hardening, however, are more restricted for nitriding than for carburizing.

Flame hardening of steels is a recent process development becoming more popular because of simplicity of the apparatus required. It depends upon surface transformation of the steel by localized rapid heating and cooling. Applications are diverse, as evidenced by its use for ball bearings, shafts, and gears.

Surface hardening by diffusion of substitutional elements is an extremely broad field including such processes as Calorizing, scherardizing, siliconizing, and chromizing. The principal utility arises from heat and corrosion resistance, but the improved hardness frequently renders the base metal highly wear-resistant.

Facing and Coating Materials

Since the field is so broad, this review covers recent work on wear-resistant materials applied by plating, weld-overlay, spraying, and related methods only.

Hard chrome plating of components, dies, and tools competes favorably with carbides and other surface-hardening methods for many wear-resistant applications. The chrome plating hardness range is 700-1200 Vickers compared to 900 Vickers for hardened steel and 1000 Vickers for nitrided steel. Hard chrome plate is useful for its low friction property, and also for building up worn surfaces. Techniques for getting an adherent chrome plating on hard tool steels include prior stress relief. Recent chrome-plating developments have improved adherence and structure of the deposits.

Weld overlays of hard metals, or tough metals with hard filler materials, have been used for many years. A special development of this technique is a stainless-steel overlay on cast-steel turbine blades.

Metal spraying for building up shafts and bearings has become well accepted. Several extensions of the method and new developments of a similar nature are noteworthy. An application of metallizing with a hard sprayed coating — Rockwell C56-61 — has been used for wear - resistant pump plungers and shafts. The low-carbon steel surfaces are ground to size and grit-blasted prior to spray welding.

The Poorman Flame Plating process (Linde Air Products Co.) has now been described in detail since the patent on the process has been issued. Tungsten carbide is the only material now being Flame Plated commercially by this process. The composition of the tungsten carbide coating is 92 per cent tungsten carbide and 8 per cent cobalt. Other coating materials are in the developmental stage. The range of base materials that can be coated is almost limitless. The big application now is wear resistance, particularly on parts that do not require the use of more massive carbide inserts, or which require large wear-resistant surfaces.

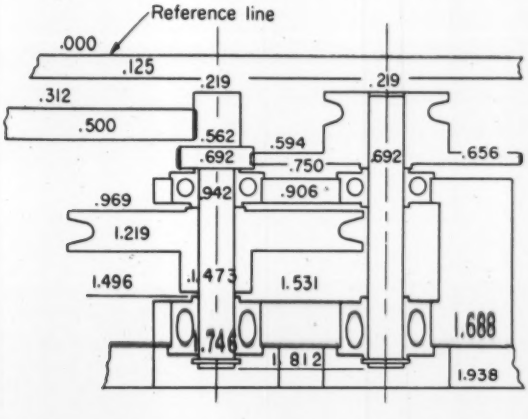
Structure of the Flame-Plated deposit is extremely fine-grained and dense. The tungsten-carbide coating can be used up to the oxidation temperature of cobalt, or about 800 F. The fine laminar structure results from impact of the powdered particles which are accelerated in the rapid repeating detonation of acetylene and air in a gun. Other combustion mixtures are covered in the basic process, such as hydrogen-air and propane-oxygen, which have special advantages in accelerating certain kinds of particles. The process appears to have many applications beyond the use of tungsten carbide coatings.

Earlier, ceramic coatings developed to protect a variety of materials from heat and wear were mentioned. The adhesion of these surfaces can be made quite good if sufficient attention is given to the preparation of the surface, the thickness of the coating, and the conditions of deposition. The class of service expected from ceramic coatings is extremely varied. They have the advantage of heat and wear resistance together with resistance to metal wetting and contamination.

Tips and Techniques

Dimensioning from a Common Reference Line

A SYSTEM of dimensioning an assembly drawing from one reference line has many advantages. For example, the method helps in arriving at proper detail dimensions, checking part relationships, and keeping records. A change in one dimension requires changing only one number, where, if the drawing were dimensioned in the conventional manner, several numbers might have to be changed.



An example, see sketch, of a gear and pulley assembly is dimensioned from the top surface. Each pertinent vertical distance is represented by the figure directly above the surface. No leaders or arrows confuse the picture. Every thickness, length, clearance or other vertical relationship may be found by one simple subtraction.—MORTON P. MATTHEW, *Arehndt Instrument Co., College Park, Md.*

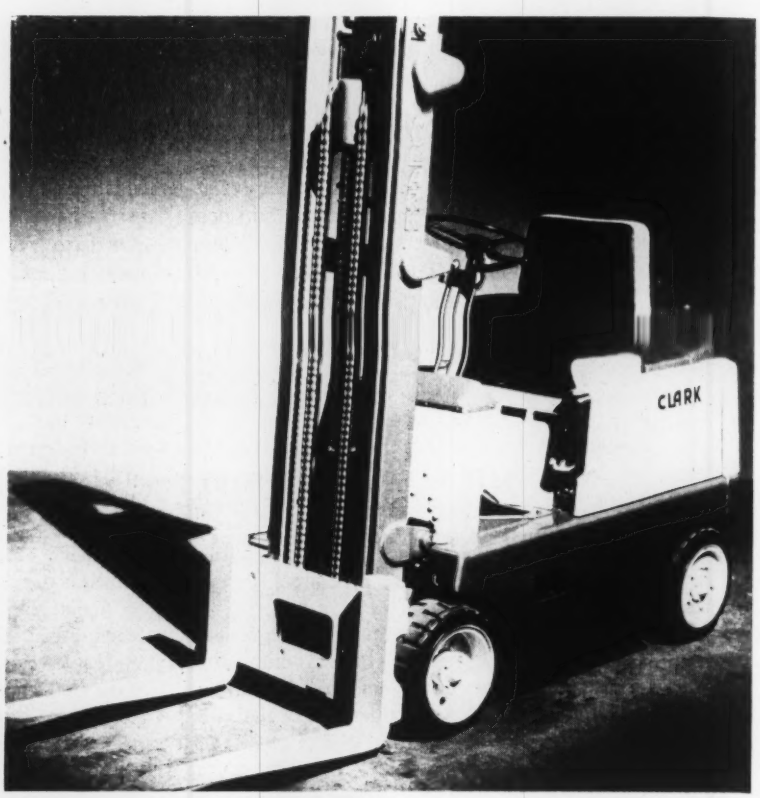
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

DESIGN FOR QUICK DISASSEMBLY

MANEUVERABILITY, easy handling and simplified maintenance have all been considered in the design of a new line of fork-lift trucks. Available in gasoline engine-powered models with lifting capacities from 2000 to 5000 pounds, the trucks have been labelled Clarklift, and are described as an elite line by their manufacturers, Clark Equipment Co.

Nested uprights increase operator vision. Maneuverability and ease of handling have been improved by such design features as a completely automatic transmission with a sensitive inching control, rear steer wheels with the same diameter as the front drive wheels, a reduction in length from the front axle to the face of the fork of 2½ in., and substantial weight reduction.

Of particular interest is the inching valve. This permits precise, smooth forward or backward movement of the truck even though the engine is running at high rpm to drive the hydraulic pump supplying oil to the lifting and tilting cylinders.



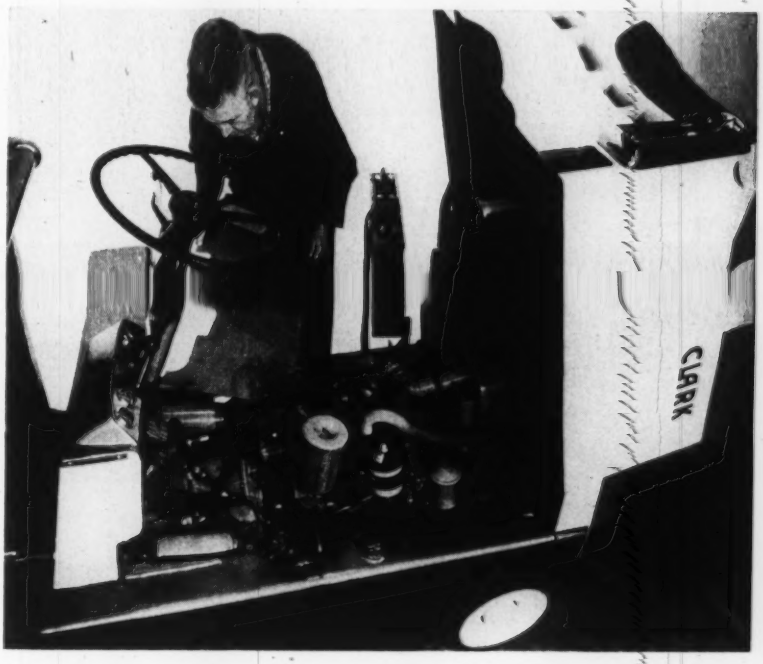
The inching valve is operated by the first 1¾ in. of brake pedal movement regardless of brake lining wear. With the brake pedal depressed the full 1¾ in. or more, a small amount of oil is applied to either the forward or reverse clutch pack in the transmission to lightly engage the pack. The brakes hold the truck and prevent motion. As the pedal is released, the inching valve meters more oil to the appropriate clutch pack to provide controlled movement of the truck.

CONTEMPORARY DESIGN

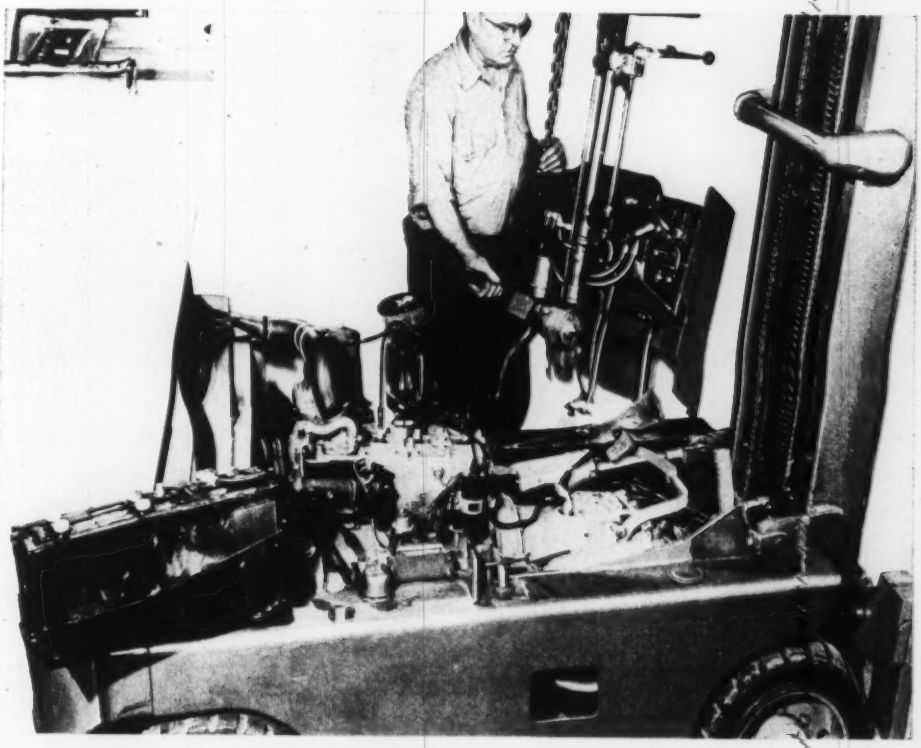
SIMPLIFIES SERVICING

Self-adjusting brakes, high interchangeability of components between different models of the line and other features which simplify servicing as well as component or part replacement contribute to increased ease of maintenance.

Engine accessibility is excellent. A balanced, one-piece, swing-up hood completely exposes the engine, radiator and battery when raised. Ignition distributor, air cleaner, oil filter and other such components are exposed for adjustment or other service operations. A swinging battery tray can be quickly pivoted out of the way. Quick access to the torque converter and transmission is provided by a floor plate which is quickly removable since it is held by only four screws.



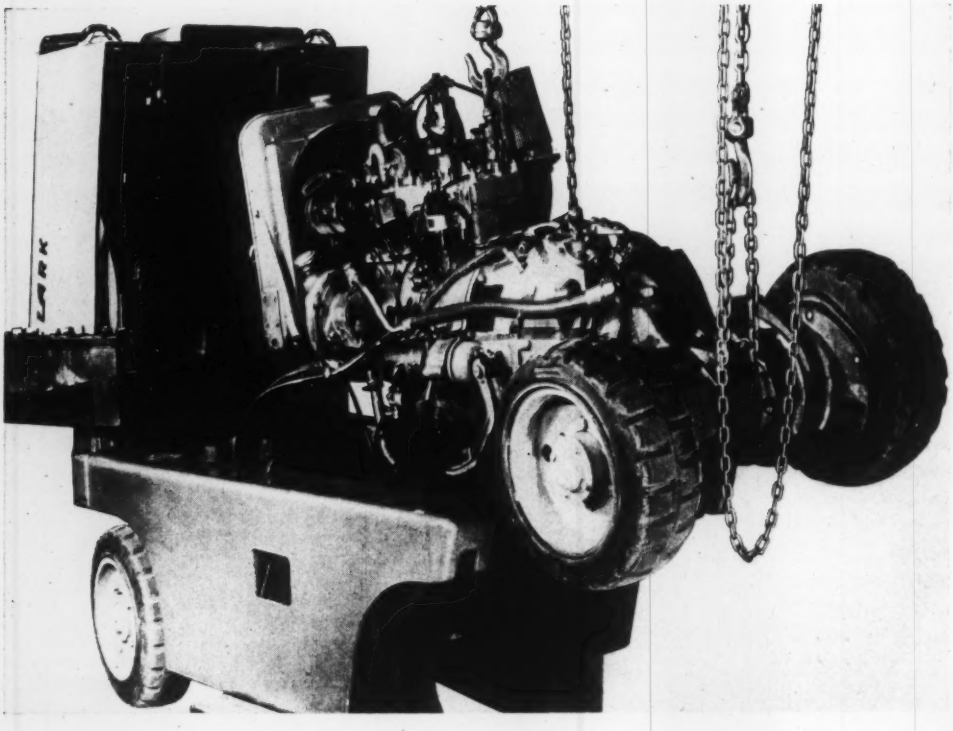
Major servicing or unit replacement is facilitated by design for ease of dis-



assembly. Quick removal of the entire dashboard is aided by a quick disconnect multiple plug which permits instant disconnection of all wiring.

The entire fork-lift assembly is removable by disconnecting one hose, the two lift cylinders and removing four bolts holding the trunnion caps.

Power train, consisting of engine, transmission and drive axle, is easily pulled by removing six bolts which hold the drive axle to the frame and one bolt from the engine mount at the other end of the truck. The two tilt cylinder pins must also be removed as well as the brake pedal.



CONTEMPORARY DESIGN

Basic Cam Systems

. . . a guide to selection of cam and follower types

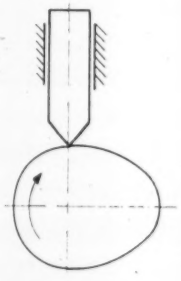
By Harold A. Rothbart

Assistant Professor of Mechanical Engineering
City College of New York
New York, N. Y.

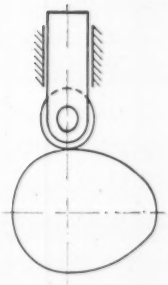
Besides offering a wide choice of input-output relationships, cam mechanisms can be designed in a variety of physical forms. This article, as a brief guide to cam selection, shows some of the more useful cam-follower systems classified according to six bases.

1. Follower contact
2. Follower motion
3. Follower position
4. Cam motion
5. Cam shape
6. Follower constraint

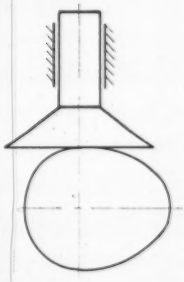
1. Follower Contact



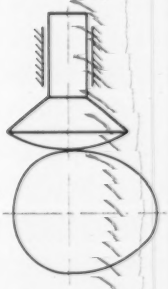
1.1
Knife-edge or point follower. Construction is simple but edge wears rapidly.



1.2
Roller follower. Action is pure rolling at low speeds; some sliding motion at high speeds. Follower may jam if cam profile is steep.



1.3
Plane-face follower.
Has advantage over roller since it will not jam when used with a steep cam. May incur high surface stresses if deflected or misaligned.

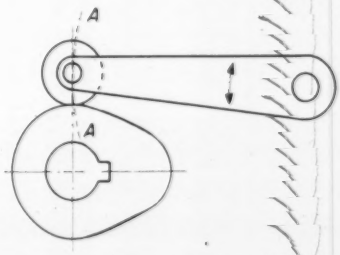


1.4
Spherical-face follower. Large radius on face compensates for possible deflection or misalignment.

2. Follower Motion

2.1
Translating follower (see 1.2).

2.2
Swinging follower (see also 5.8).

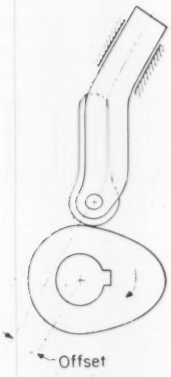


Cams

3. Follower Position

3.1
On-center follower (see 1.2). Axis of follower motion passes through center of cam rotation.

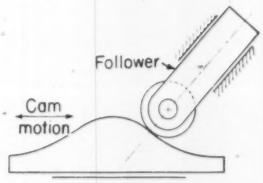
3.2
Offset follower (see also 4.2). Usually offset in direction that reduces force components tending to create jamming.



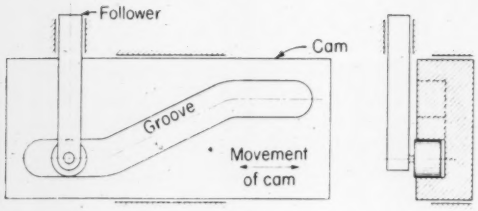
4. Cam Motion

4.1
Rotating cam (see 1.2, 5.2, 5.7).

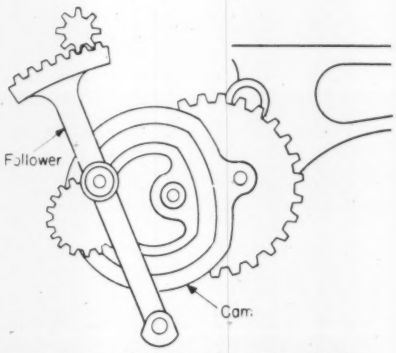
4.2
Translating cam (see also 5.1).



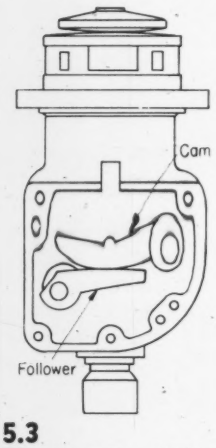
5. Cam Shape



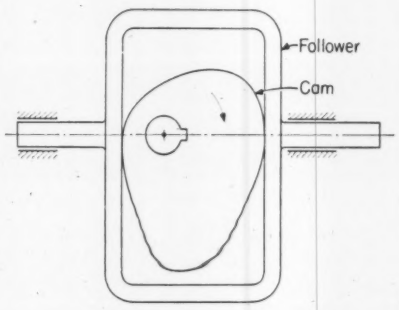
5.1
Flat-plate cam. Positive-drive version of simple wedge cam.



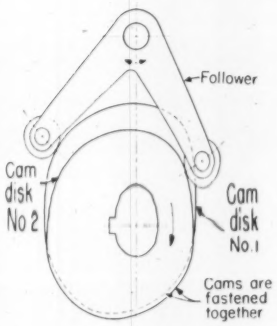
5.2
Face-groove or plate-groove cam. Roller in groove constrains follower to positive-drive action.



5.3
Wiper cam. Curved cam drives flat-faced follower.

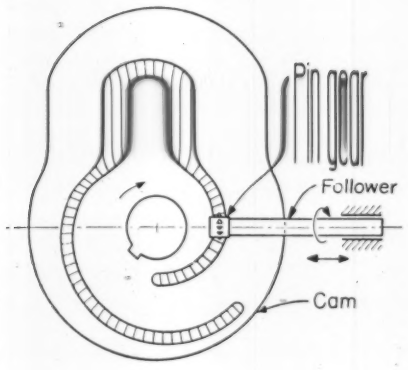


5.4
Yoke cam. Opposite surfaces of follower ensure positive drive. Control of follower action limited to 180 deg of cam rotation; remaining 180 deg are complementary to maintain the fixed-distance contact on the cam.

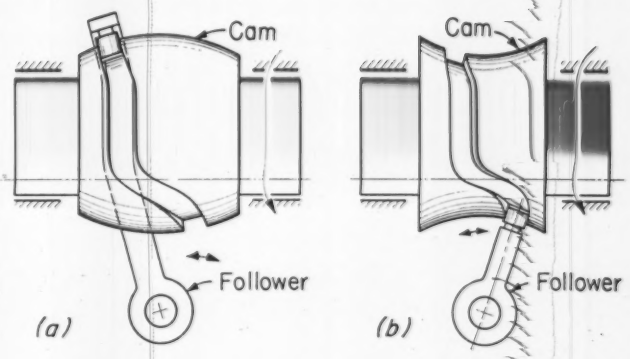


5.5
Double-disk cam. Preloading rollers against each other minimizes backlash in follower motion.

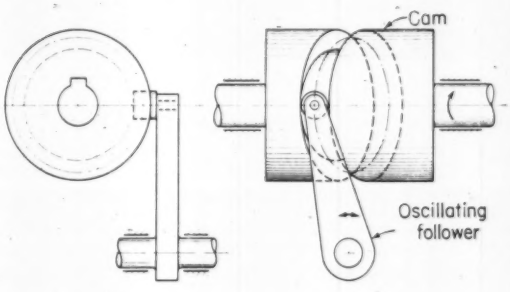
5. Cam shape (Continued)



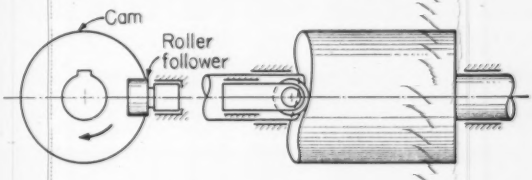
5.6
Spiral cam. Has pin-gear follower driven by teeth in cam groove.



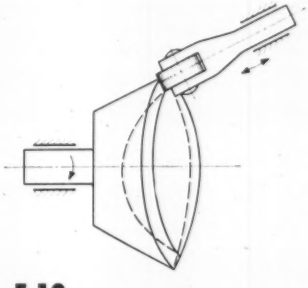
5.7
Globoidal cam. (a) convex; (b) concave. Shape determined by arcs swept by oscillating followers. Backlash in follower grooves affects accuracy at high speeds.



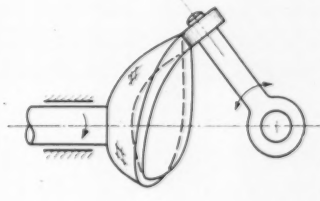
5.8
Cylindrical cam. Special form of globoidal cam.



5.9
End cam. Has working surface at end of rotating cylinder.

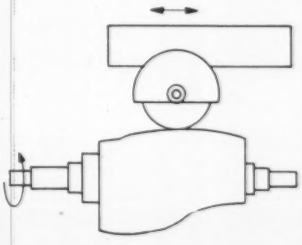


5.10
Conical cam. Drives follower along axis parallel to sides of cone. May be used to change direction of motion in limited space.

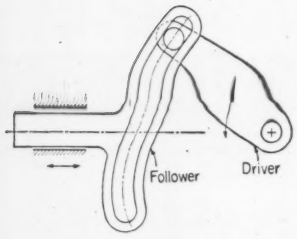


5.11
Spherical cam. Rotating portion of sphere oscillates follower with axis perpendicular to cam axis.

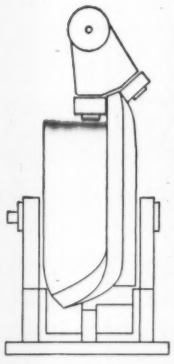
5.12
Three-dimensional cam. Rotates about longitudinal axis while translating along axis relative to follower.



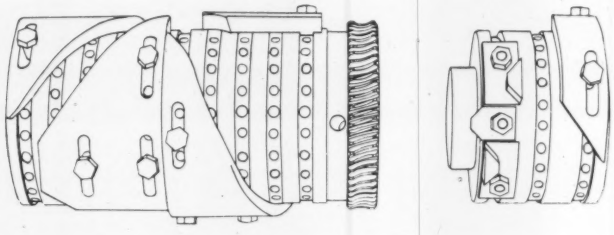
5. Cam shape *(continued)*



5.13
Inverse cam. Normal functions of cam and follower are reversed; oscillating roller drives contoured follower.



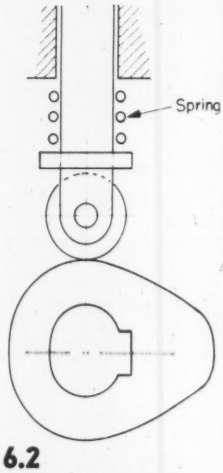
5.14
Roller gear-drive cam. Has projected single thread in contact with dual-roller follower. Performance excellent at high speeds.



5.15
Adjustable cam (also clamp, strap, dog, or carrier cam). Cam contours are removable pieces bolted to supporting cylinder.

6. Follower Constraint

6.1
Gravity constraint (see 1.2).



6.2
Spring constraint.

6.3
Positive-constraint (see 5.1, 5.5, 5.7, 5.14).

This article is based upon information appearing in a forthcoming book, *Cams—Design, Dynamics and Accuracy*, to be published by John Wiley and Sons Inc., New York.

DESIGN ABSTRACTS

Basic principles of

Heat Transfer

HEAT or thermal energy is transferred from one region to another by virtue of temperature difference. The two fundamental axioms are that heat flows only from a high temperature region to one of lower temperature, and that heat emitted by the high-temperature region must be exactly equal to that absorbed by the low-temperature region.

When heat is transferred at a steady rate, and the temperature at any given point is constant, the steady state is said to exist. On the other hand, if the heat flow is a function of time, the flow is said to be in the unsteady state. An example of the latter is the warm-up period of an electronic assembly.

In general, there are three modes or methods of heat transfer: conduction, convection, and radiation. They may occur singly or simultaneously. Although evaporation and condensation may be classified under convection, they are usually considered separately since mass transfer, as well as heat transfer, occurs.

Conduction: The basic law of heat conduction in the steady state and in its most simple form (heat transfer through a wall) is:

$$q = k \frac{A}{L} (\Delta t)$$

where q = rate of heat transfer; k = thermal conductivity of the material; A = cross-sectional area perpendicular to the direction of heat flow; L = length of heat flow path; (Δt) = temperature difference causing heat flow.

Thermal conductivity k is the quantity of heat which will flow across unit area in unit time when the length of heat path is unity and the temperature gradient across this path is unity. Its numerical value depends on the material, being high for metals and low for insulators. For example, the thermal conductivity of copper is over 300 times that of glass.

Convection: The process of heat transfer from the surface of a solid to moving masses of fluids, either gaseous or liquid, is known as convection. This mode of heat transfer is brought about mainly through circulation of the fluid.

For example, the surface of a warm object situated in still air at a lower temperature heats the air adjacent to the surface. The heated air becomes less dense as its temperature increases and induces convection currents. When the circulation is caused only by differences in density, the process is called natural or free convection. Circulation may be forced mechanically by blowers, pumps, and the like, in which case the heat transfer is called forced convection.

The mechanism of convection may be explained by considering a cool stream of air flowing past a heated surface. Immediately adjacent to the surface there exists a film of air varying in velocity from zero at the surface to the velocity of the main stream at its outer side. This film offers resistance to heat flow and is influenced by the nature of the flow.

In free convection the film is usually in laminar or streamline motion and relatively thick, causing high resistance to heat flow. However, in forced convection, the higher velocity tends to decrease the thickness of this film, improving the heat transfer.

The basic equation for convection is:

$$q = h_c A (\Delta t)$$

where q = heat transfer rate; h_c = convection coefficient of heat transfer; A = surface area; and (Δt) = temperature difference between the surface and the main fluid stream.

The value of h_c is influenced by many factors including not only properties of the fluid such as viscosity, density, etc., but flow conditions and surface characteristics as well.

Evaporation and Condensation: Evaporation and condensation are characterized by a change of state

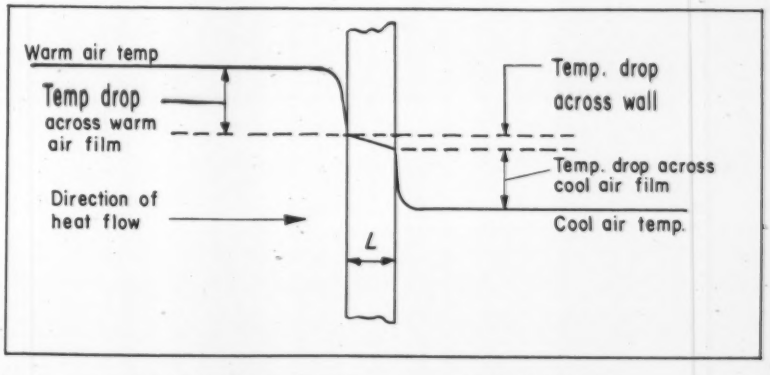


Fig. 1—Temperature gradient through a wall.

involving a liquid evaporating to the vapor state and a vapor condensing to the liquid state, respectively. The basic equation for these processes is the same as that for convection.

The amount of heat necessary to evaporate a unit mass of a liquid to a vapor is called the heat of vaporization. Evaporation usually involves high rates of heat transfer and the coefficients may be as much as 200 times that for air in forced convection.

During condensation the heat of vaporization is released. Like vaporization, high rates of heat transfer are usually associated with condensation.

Radiation: Bodies under thermal agitation induced by heat emit thermal radiation in the form of electromagnetic waves ranging in wave length from the long infrared to the short ultraviolet.

Radiation emitted from a body can travel undiminished through a vacuum or through gases with relatively little absorption. When radiation is intercepted by a second body, part may be absorbed as thermal energy, part may be reflected from the surface, and part may be transmitted still in electromagnetic wave form through the body, as in the case of glass.

Consider a body in space receiving radiant energy from some source. If all the incident radiation is absorbed with zero energy being reflected or transmitted, it is a perfect absorber and called a "blackbody."

There are no perfect absorbers in nature, although some bodies come very close to exhibiting blackbody characteristics. The ratio of the amount of energy absorbed by an actual body to that by a thermal blackbody is called the "absorptivity."

In the absence of conduction and convection, a body at thermal equilibrium which receives radiation must necessarily emit radiant energy equal to that absorbed. Hence a body which is a good receiver or absorber is a good radiator or emitter.

The ratio of the amount of radiant energy emitted by an actual body to that emitted by the ideal blackbody is called the "emissivity" and is numerically equal to the absorptivity.

Its numerical value is always less than unity. The emissivity of polished copper, for example, is 0.023, whereas that of oxidized cast iron may be as high as 0.95.

The basic equation for the radiation from a blackbody is:

$$q = \sigma A T^4$$

where q = rate of energy emitted by a blackbody; σ = the Stephan-Boltzmann constant; A = surface area; and T = absolute temperature.

For actual bodies, the preceding equation must be modified for departure from ideal blackness and, since the net exchange of radiant energy between two bodies is usually required, it must be modified depending on the geometry of the system. The general equation for the net rate of exchange of radiant heat between two nonblack bodies is:

$$q = F_e F_a A \sigma (T_1^4 - T_2^4)$$

where F_e = emissivity factor to allow for departure from blackbody conditions; F_a = configuration factor based on the geometry of the system (not all of the radiation emitted by a body may be intercepted by the second body); and T_1 and T_2 are the temperatures of the hot and cold bodies respectively.

Net radiation between two bodies is thus proportional to the difference in fourth powers of absolute temperatures, whereas conduction and convection in general are proportional to difference in first powers of the temperatures.

Convection and radiation may occur simultaneously to provide parallel heat flow paths. The resistance concept may be applied to radiation by considering a fictitious radiation coefficient, h_r, such that the convection and radiation coefficients are additive when a surface loses heat by both modes. The radiation coefficient is defined as:

$$h_r = \frac{q}{A (\Delta T)}$$

Thus, considering the equation already given for convection, the total heat transferred from a surface is:

$$q = (h_c + h_r) A (\Delta T)$$

An electronic box situated in a lower temperature environment might lose heat by both convection and radiation from its outer surfaces.

Consider a wall as in Fig. 1 with air on one side at a higher temperature than the air on the opposite side. Neglecting radiation, Fig. 1 shows the temperature gradient from warm air to cool air. Heat is transferred by convection across the air film, then

Table 1—Typical Heat Transfer Rates

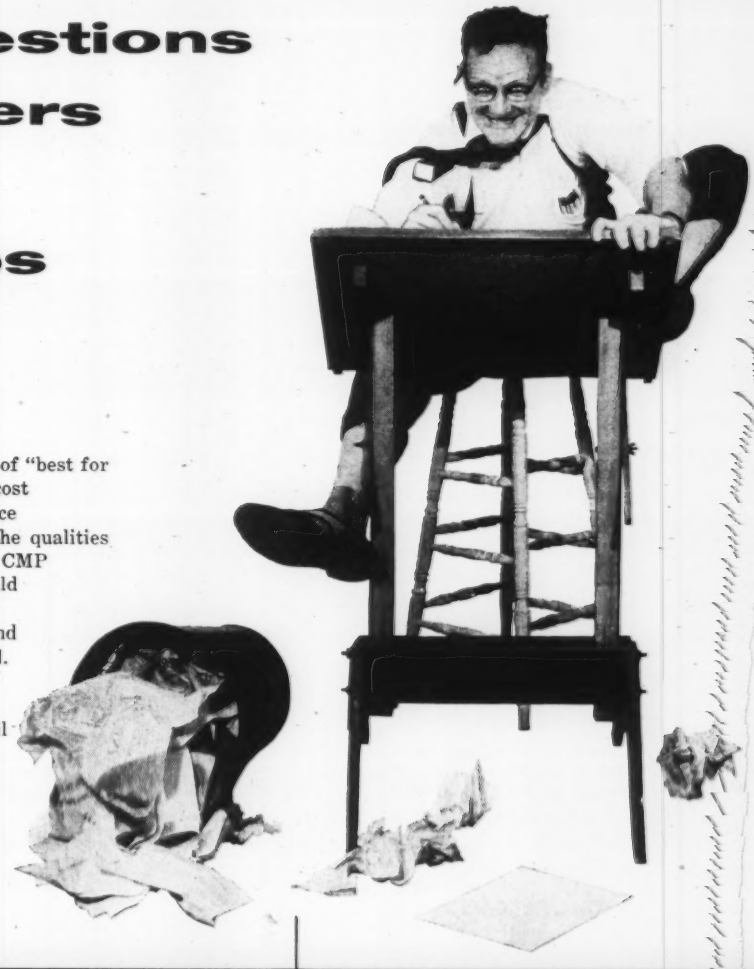
Process	Heat Flow (Btu/hr/sq ft/deg F)	Heat Flow (Watts/sq in./deg C)
Conduction		
Copper, 0.1-in. thick	26,160.00	95.20
Pyrex glass, 0.1-in. thick	87.36	0.322
Cork board, 0.1-in. thick	3.0	0.011
Free convection		
From vertical plate 6 in. high at 120 C, air at 80 C	0.96	0.00348
Forced convection		
Air over 6-in. plate at 8 ft/sec, mean temperature air and plate of 100 C	2.84	0.0104
Water at 40 C flowing at 5 ft/sec in 2-in. diam pipe	1420.00	5.19
Evaporation		
Water boiling on flat plate at atmospheric pressure	2000.00	7.30
Condensation		
Steam on flat plate at atmospheric pressure	1000.00	3.65
Radiation between two blackbodies		
At 100 C and 50 C	1.72	0.0063
At 500 C and 50 C	7.81	0.0287

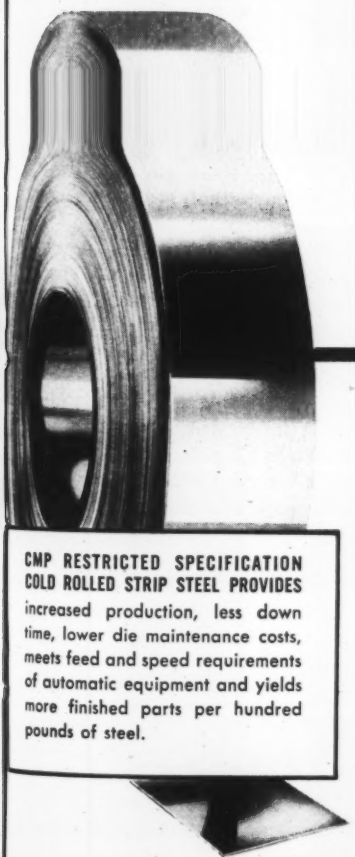
Facing Page—ITEM 612→

CMP suggestions for designers of better mousetraps

and other important metal products requiring cold rolled strip steel

When you're planning products on the basis of "best for the job," the material specification and its cost becomes important in relation to performance and yield. And when you are considering the qualities of cold rolled strip steel available, such as CMP restricted specification strip steel, you should know that CMP can supply many unusual advantages in physicals, close tolerances and finishes that make your job most successful. It can help you achieve the end result you want and assist in fabrication and assembly by supplying the uniformity in coil after coil of the desired pre-planned specification. Note now the range of precision cold rolled strip steel products CMP can supply. For more information write today.





CMP RESTRICTED SPECIFICATION COLD ROLLED STRIP STEEL PROVIDES increased production, less down time, lower die maintenance costs, meets feed and speed requirements of automatic equipment and yields more finished parts per hundred pounds of steel.

SPRING STEEL

Cold Rolled, Annealed and Completely Spheroidized or Hardened, Tempered and Polished—.50% to 1.35% carbon. Any practical controlled structure to meet fabricating, heat treating and service requirements.

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All A.I.S.I. Types and Grades and government specs. to special specifications for physicals. Bright Annealed Chrome-Nickel and Chrome Stainless Grades, High-Tensile and High Hardness Stainless.

LOW CARBON

All carbon ranges — annealed, intermediate or hard-rolled tempers. Non-scalloping quality and other special specifications can be furnished for most efficient fabrication and best end product performance.

ELECTRO ZINC COATED

Ductile, tight-adhering dense zinc coating on phosphate base withstands tough fabrication, gives highest corrosion resistance. Suitable for painting or enameling.

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SALES OFFICES: NEW YORK CLEVELAND DETROIT INDIANAPOLIS CHICAGO LOS ANGELES SAN FRANCISCO

CMP

by conduction across the wall, and finally by convection to the cooler air. Since this is a thermal series circuit involving three resistances, the equation for the heat flow would be:

$$q = \frac{(\Delta t)}{\frac{1}{Ah_c} + \frac{L}{Ak} + \frac{1}{Ah_c}} = \frac{(\Delta t)}{\Sigma R}$$

where (Δt) = difference between the warm and cool air temperatures; h_c = convection coefficients of the warm and cool air films, respectively; and ΣR = total resistance to heat flow.

Each term in the denominator of this equation represents a thermal resistance analogous to the resistances in a simple series electrical circuit.

Temperature drop or gradient across each resistance is proportional to the resistance. Thus, the temperature drop across the wall, (Δt_w), for example, is:

$$(\Delta t_w) = \frac{\frac{L}{Ak}}{\Sigma R} (\Delta t)$$

Ultimate Sink: Unlike the closed electrical circuit, the thermal circuit is an open one. The heat generated in a vacuum tube, for example, is transferred by various modes through various channels and ultimately reaches a heat sink. The cooling process is simply one of transporting thermal energy from a heat source to a heat sink at a lower temperature.

The design problem is to provide a thermal path of low resistance and a low-temperature sink so that the temperature of the heat sources will not be excessive. Further, nonheat-producing sources critical to temperature must be protected from overheating.

In the final analysis the ultimate sink is the earth's atmosphere, large bodies of water, or the earth itself. However, from the practical view, the designer may have available intermediate sinks such as cooled air which must transport the heat from the electronic assembly to the ultimate sink.

Heat Transfer Processes: Relative magnitude of various heat transfer processes are shown in Table 1. The values listed are representative only and may vary with conditions. Comparison is made on the basis of conductance, which is heat transfer rate per unit area per degree temperature difference. In free convection from the vertical plate, for example, conductance is reported per degree difference in plate and air temperatures.

From "Introduction to Heat Transfer" in Bureau of Ships Journal, *February,* 1956.

Nomogram aids in

Selecting Electric Motors

for fan and centrifugal pump type loads

By C. G. Veinott

Reliance Electric & Engineering Co.
Cleveland

THE NOMOGRAM described in this article, Fig. 1, was developed primarily for application of electric motors to fans. It is equally useful in application of motors to centrifugal pumps, or to similar devices which have the characteristic that torque required varies as the square of speed, or that power varies as the cube of speed. Even though these were primary purposes, the nomogram is also useful and convenient in working out relationships between torque, power and speed for any case, making it easy to find any one of these three when the other two are known.

This nomogram is based upon the following familiar equation:

$$\text{Power} = \frac{\text{speed} \times \text{torque}}{C}$$

where C is a constant which depends on units used for power and torque.

The reference axis has been so drawn that if a straight-edge is turned about any point on it, torque indicated will be directly proportional to the square of the rpm, and power indicated will be proportional to the cube of the rpm.

Torque Scale: In Fig. 1, the torque scale is ruled with pound-feet on one side and ounce-feet on the other. The scale in pound-feet is direct reading when the upper rpm scale (usually used for integral-hp motors) is used. The ounce-feet scale on the right is direct reading if the lower rpm scale (usually used for fractional-hp motors) is used.

If it is desired to read torque in ounce-feet when the upper rpm scale is used it is necessary to multiply the actual scale reading by 10. (See Example 1.)

If it is desired to read the torque in pound-feet when the lower rpm scale is used, it is necessary to divide the actual scale reading by 10. (See Example 2.)

Power Scale: The power scale in Fig. 1 is divided into watts on the right-hand side. Horsepower divisions, corresponding to the usual ratings of induction motors, are marked on the left side of this scale.

Speed Scale: The speed scale is divided into two rpm scales. The upper one is intended primarily for use with motors of integral horsepower rating, and with the pound-foot scale of torque. The lower rpm scale is principally intended for use with fractional horsepower

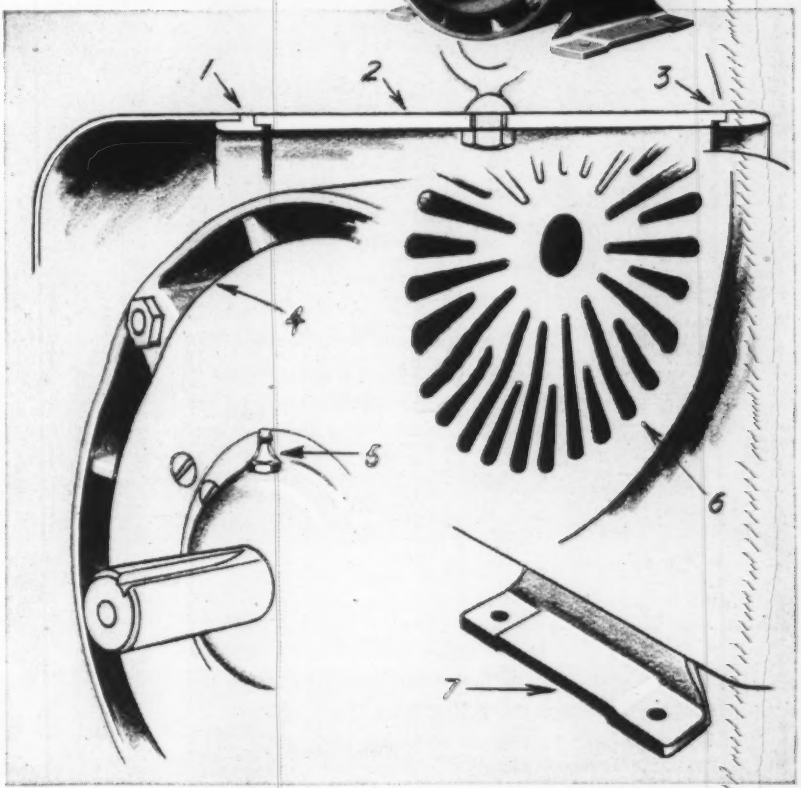
HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Eye Appeal: New Requirement in Motor Design

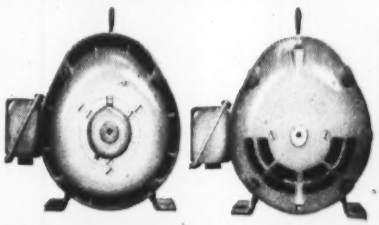
As the trend to automation accelerates and the number of individual drives per machine increases, electric motors become, more than ever, an important element in the overall appearance of many machines. In designing the Howell Series 100 motors in the new frame sizes, Howell engineers set up the list of design requirements shown below. For evidence of how they met them, see the totally enclosed fan cooled motor at right and the detail sketches below it.

When you're specifying motors, why not specify for streamlined appearance – in addition to the top performance you need? It's a bonus value that costs no more and you'll be matching functional efficiency with sleek good looks.



HOWELL SERIES 100 TEFC EXTERIOR DESIGN REQUIREMENTS

1. Fan cover, end-plate and frame to join so as to produce flush exterior surface.
2. No fins, ribs or other protrusions, other than conduit box and feet, around entire diameter of frame.
3. Joint between frame and end-plate to present flush exterior surface.
4. Ventilation ports to carry out contemporary streamlining, offer minimum obstruction to passage of air, and meet or better NEMA specifications for safety.
5. Grease fittings, top-ball type, to be located for (1) easy accessibility (2) maximum protection against damage.
6. Fan guard openings to incorporate distinctive design and to meet or exceed NEMA specifications for safety.
7. Mounting feet to eliminate excess bulk and weight, utilize steel's strength to best advantage. Contours to present good appearance.



Open-type motors in the Howell Series 100 line match their TEFC counterparts not only in streamlined good looks, (see above right), but in diameter and mounting dimensions. Space allocations are simplified.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, and totally enclosed non-ventilated.

Get complete details on these outstanding new motors today . . . write for Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

—ITEM 613—

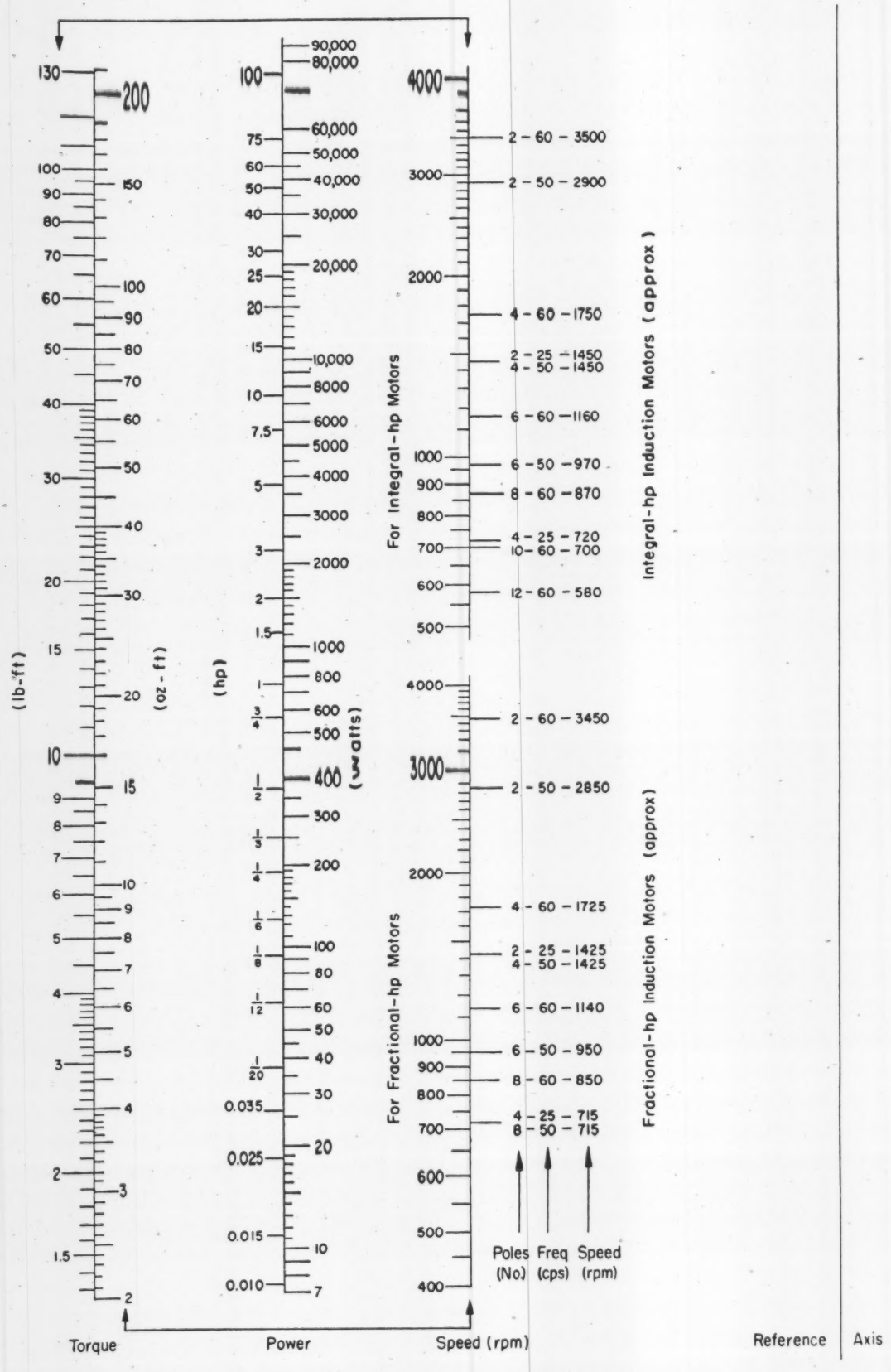


Fig. 1—Nomogram for application of motors to fans and similar devices.

When a product design can be simplified

Has greater strength . . . higher rigidity

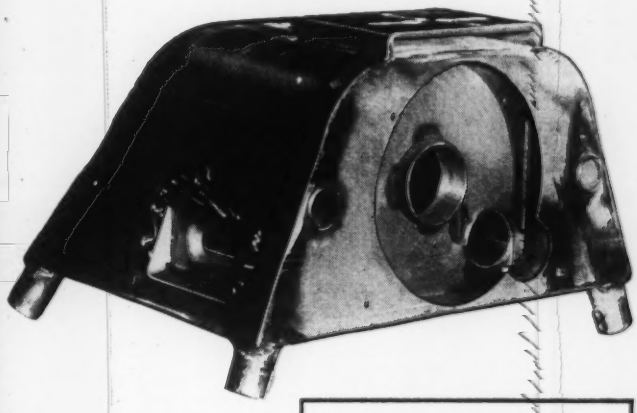
Yet takes less material . . . costs less to produce

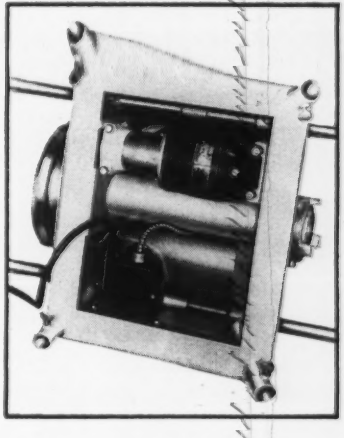
WHY

use anything but welded steel

STEEL DESIGN CUTS WEIGHT AND COST

. . . without sacrificing strength and rigidity





All-welded headstock *for power drive is made from 16 gauge sheet. Estimated to be 20% more rigid, weigh 28% less, cost 44% less than cast iron design. Photos courtesy Oster Manufacturing Company, Cleveland, O.*

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ratings and with the ounce-foot scale of torque. One of the main reasons for having two rpm scales is to avoid having the straight-edge cross the chart at sharp angles. A second reason is to show different full-load speeds for motors of fractional horsepower than for those of integral-horsepower ratings. The right side of each rpm scale is marked with divisions at the most common full-load speeds of induction motors. The poles and frequency corresponding to these speeds are also given. Any intermediate speed, of course, can be read by using the left side of the scale.

Reference Axis: As stated before, the reference axis has been so located that any single point on it can be used as a turning point, and thus indicate a full horsepower versus rpm curve for any one fan under any one specified condition.

Using the Chart: Uses of the chart can be illustrated by examples:

EXAMPLE 1: Find the full-load torque of 1½-hp, 1160-rpm motor. Refer to Fig. 2. Lay a straight-edge across 1.5 hp and 1160 rpm. Extending the line to the torque scale, read the answer: 6.8 lb-ft. (The ounce-feet scale shows 10.9, so the ounce-feet torque would be 109.)

EXAMPLE 2: A blower requires 1½ hp to drive it at 3500 rpm. How much power does it take to drive it at 2900 rpm, and how much torque? Refer to Fig. 3. The required motor, rated at 1.5 hp at 3500 rpm is normally considered as an integral-horsepower rating, but if we attempt to lay the straight-edge across 1.5 hp and 3500 rpm on the integral horsepower rpm scale, the straight-edge will intersect the reference axis well off the paper. This difficulty can be avoided by using the fractional-horsepower scale, using the 3500 rpm marking, rather than the 3450 rpm marking, obtaining the point *B* on the reference axis. Then a line is drawn from *B* to the 2900 rpm point, also on the fractional-horsepower scale. Its intersection with the power axis shows that the power requirement is 640 watts or between ¾ and 1 hp. (The power scale is direct-reading regardless of which speed scale was used.) The torque required can be read directly in ounce-feet on the torque scale; it is 25. If the torque is desired in pound-feet, it can be read as 15.6 and divided by 10, obtaining 1.56 lb-ft torque.

Other Uses: These examples illustrate typical uses of the nomogram. It is also useful as a means for recording speed-torque and speed-power characteristics of a large number of fans. Points marked on the reference axis are labeled to indicate the fan to which each point is referred. From the single point on the alignment chart, torque or power required by any one of the fans at any speed is very quickly obtained. This is particularly useful in determining which fan is best suited for testing any particular motor of any given horsepower and speed rating.

From a paper entitled "Alignment Chart to Simplify Fan Motor Selection" presented at the AIEE Conference on Application of Motors to Space Heating and Cooling Equipment in St. Louis, Mo., October 1955.

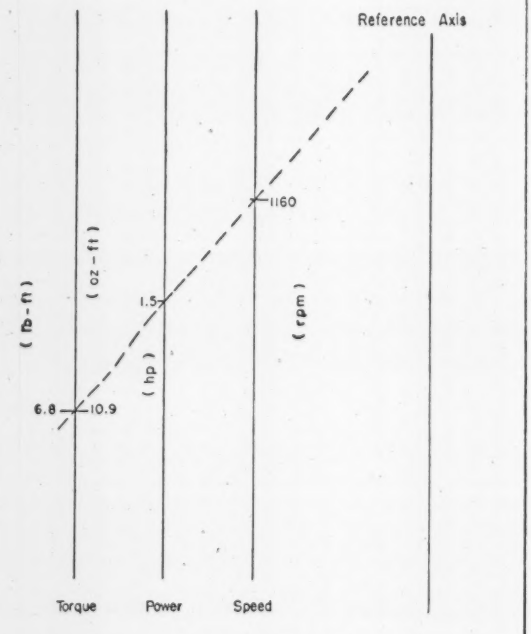

Fig. 2 — Use of nomogram to solve Example 1. Ounce-foot scale reads 10.9, so true ounce-foot torque is 109.

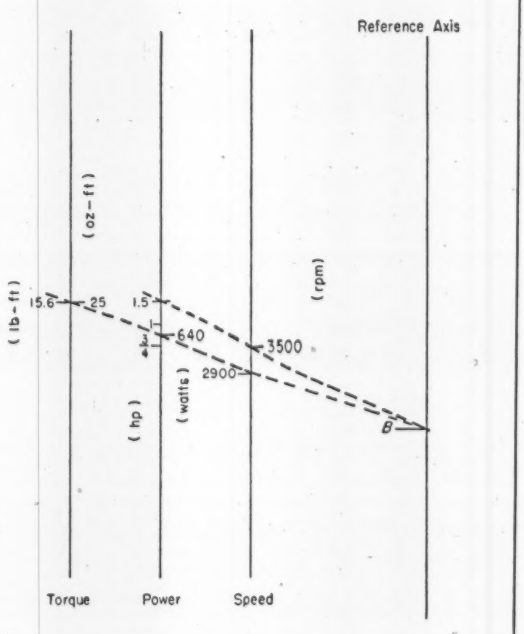

Fig. 3—Solution of Example 2.

"And I Said I'd Never Use a Drafting Machine"

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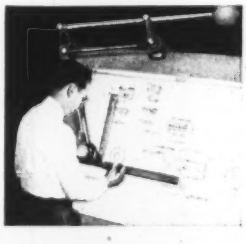
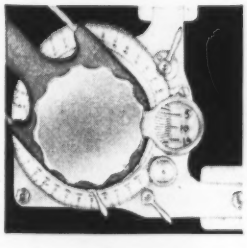


Bruning Counterbalanced Drafters and Bruning Track Drafters provide fast, easy, accurate drafting on vertical boards and on extra-large drawings.



Bruning Equipoise Drafters are available with either the Civil Engineer protractor head, shown here, with its special azimuth scale, or the Standard protractor head.

Take a tip from an increasing number of draftsmen who, perhaps like yourself, were reluctant to try any drafting machine or had been disappointed in a conventional type drafter. These men now report: Bruning Equipoise Drafters cut drafting time over conventional equipment up to 40% on most jobs, up to 50% on some structural drawings—beat any other drafting machine they ever tried.

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—ITEM 615—

HELPFUL LITERATURE
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Chemical Rubber

How Hypalon chemical rubber has solved numerous problems in product design and plant maintenance calling for rubber products with resistance to deterioration is related in illustrated booklet A-509. Examples of how its characteristics have benefited users of hose, belting, seals, coatings and other products. 8 pages. E. I. du Pont de Nemours & Co.

—Circle ITEM 401

Speed Reducers

Details of Cone-Drive shaft-mounted speed reducer line which utilizes the double-enveloping worm gear design are found in illustrated bulletin CD-400. Dimensioned assembly drawings, horsepower and torque charts and application photos are given, along with complete specifications. 12 pages. Michigan Tool Co., Cone-Drive Gears Div.

—Circle ITEM 402

Pyrex Heat Exchangers

Edge-indexed for reading convenience, bulletin PE-33 will help in choosing the right modular glass shell and tube heat exchanger. Ten engineering drawings show how heat exchanger modules can be installed. Charts cover fluid constants, friction losses, surface area calculations and thermal gradients. 16 pages. Corning Glass Works.

—Circle ITEM 403

Multiple V-Belt Drives

Origin, history and development of the multiple V-belt drive is discussed in pocket-size booklet 20E8297. The evolution of standards in engineering V-belt drives is also covered. Basic principles and practices involved in engineering and use of drives are expressed in question and answer form. 36 pages. Allis-Chalmers Mfg. Co.

—Circle ITEM 404

Air Conditioning Components

Torque converters, radiators, clutches, oil coolers, heat exchanger coils and components for air conditioning in automotive, agricultural, commercial and industrial vehicles are described and illustrated in booklet "Long Designs and Makes Them Better." Research, development and manufacturing facilities are also explained. 16 pages. Borg-Warner Corp., Long Mfg. Div.

—Circle ITEM 405

Steel Hardening Process

Pocket-size booklet describes "Super Scottsonizing," a process for hardening stainless steel parts which are already finished to size. It will harden stainless steel to an estimated 2000 Brinell. Wide variety of treated parts are shown. 64 pages. C. U. Scott & Son, Inc.

—Circle ITEM 406

Nylon Molding Powder

Folder-type bulletin describes Nylatron GS, a "moly" filled nylon molding powder which has exceptional wear and frictional properties along with resistance to heat distortion and expansion. Test data are included. 6 pages. National Polymer Products, Inc.

—Circle ITEM 407

Custom-Made Rubber Parts

Facilities for producing custom-made rubber parts and components are described in file folder. Lab facilities for compound development, fabricating techniques for producing rubber products to close tolerances and a showing of representative products are highlights. 8 pages. Goshen Rubber Co.

—Circle ITEM 408

Powder Metals

Processes used to manufacture electrolytic and reduced iron powders are described and illustrated in bulletin No. 2. Their uses in manufacturing are listed and the mechanical and electrical parts made from these powders are shown. Other powder metals are also covered. 12 pages. National-U. S. Radiator Corp., Plastic Metals Div.

—Circle ITEM 409

Custom Built Cylinders

Comprehensive data regarding design and materials used in making custom-built cylinders for 1500, 3500 psi or higher pressures are given in bulletin 79000. Units shown cover a variety of special applications. 6 pages. Oilgear Co.

—Circle ITEM 410

Spring Motor Design

General principles, physical and operational characteristics, typical applications and limitations of Neg'Ator constant-torque spring motors are discussed in bulletin 310Mb. Latest data for design of these spring motors, including procedures and formulas, are given. 25 pages. Hunter Spring Co., Neg'ator Div.

—Circle ITEM 411

Hard Surfacing Alloys

Hard surfacing alloys described in company folder are covered as to composition, welding specs, characteristics and use. Materials consist of alloy-filled tubes in coils for automatic welding, or cut to length type for manual application. 9 pages. Coast Metals, Inc.

—Circle ITEM 412

Expansion Joints

Catalog No. 53 on HydroLastic expansion joints gives details of construction and specifications, together with directions for ordering and application data for various piping systems. Joints are hydraulically formed and dynamically controlled. 24 pages. Cook Electric Co.

—Circle ITEM 413

Arc Welding Procedures

Technical Data Card 155A summarizes various recommendations for arc welding various stainless and chromium molybdenum alloy tubing steels. It provides data about preheating and postweld heat treatments, and indicates proper electrodes to use. Babcock & Wilcox Co., Tubular Products Div.

—Circle ITEM 414

Colloid Dispersions List

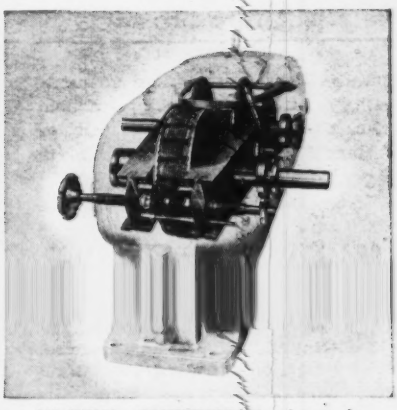
Revised "List of 'dag' Dispersions for Industry" covers 44 colloidal and semi-colloidal dispersions for operational function, maintenance, lubrication, and machine design. Eight new dispersions are included in this list. 4 pages Acheson Colloids Co.

—Circle ITEM 415

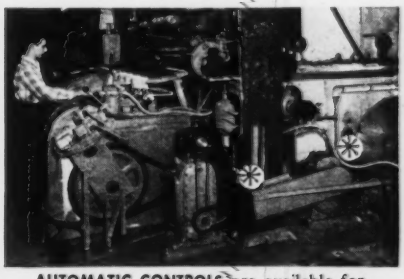
Ratchet Drive Lubricator

An automatic ratchet-driven lubricator for servicing small machines and mechanisms where installation

THREE LINK-BELT P.I.V. DRIVES on this automatic production machine allow operator to select exactly the most efficient rpm for the tool and the metal he is working. He has precise, infinitely variable control of every operation.



ALL-METAL CONSTRUCTION, shown in phantom, means long operating life with little wear and maintenance.



AUTOMATIC CONTROLS are available for self-regulation of P.I.V. This jute slasher is controlled electronically.

COMPLETE DATA. Book 2274 suggests uses for P.I.V. in timing, synchronization, many other jobs. Book 2349 covers controls.

Variable speeds, unvarying accuracy

provided by stepless, positive Link-Belt P.I.V. drives

REGULATING machine and conveyor speeds . . . synchronizing and timing operations . . . metering material flow or controlling rotary motion —for countless jobs requiring infinitely variable control of rpm, all industry uses Link-Belt P.I.V.

Whereas ordinary variable speed drives depend on friction to transmit power, P.I.V. operates with an ingenious, slipless chain. It engages in radial grooves of two sets of wheels on input and output shafts. As the operator turns the control screw, one set of wheels closes . . . the other spreads. The self-tooth-forming chain automatically adjusts itself to the wheel diameters to provide desired ratio.

This grip assures positive selection of any speed from maximum to minimum settings—with any size loads and without interrupting machine operation. P.I.V. is unexcelled for accuracy, and its principle has been proved in many years of efficient service. Performance is quiet, trouble-free, unaffected by atmospheric conditions. To learn how it can extend the useful range of your machines, call your nearest Link-Belt office.

LINK-BELT
P.I.V. VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,098

space is limited and where an oscillating drive is more readily available than rotary motion is subject of Technical Reference sheet 55B. 2 pages. Bijur Lubricating Corp.

—Circle ITEM 416

Pumping Units

Bulletin PU-3-A presents essential information on standard oil-hydraulic, vertically mounted pumping units used for many industrial machinery applications. Units are offered with 1½ to 10 hp motors and deliver 2.4 to 11 gpm at 0 psi. 2 pages. Denison Engineering Co.

—Circle ITEM 417

Polyester Film

Latest commercial uses and detailed physical and chemical properties of Mylar polyester film are reviewed in booklet MB-4. The booklet cites many industries where this plastic film has become a preferred material. 8 pages. E. I. du Pont de Nemours & Co.

—Circle ITEM 418

Liquid Chiller

Reasons for the wide acceptance of company's Dry-Ex liquid chiller are presented graphically in catalog 600. Ninety-seven standard sizes with capacities ranging from 5 through 300 tons are listed along with specifications and a simplified selection procedure. 8 pages. Acme Industries, Inc.

—Circle ITEM 419

Chemical Resistance Chart

Compatibility of nearly 400 reagents to polyethylene, nonplasticized polyvinyl chloride, high impact PVC and high tensile, high temperature polyethylene is shown in list compiled according to tests using nonstressed specimens. American Agile Corp.

—Circle ITEM 420

Helical Gear Drives

Load classes for over 250 applications of in-line helical gear drives are given in illustrated booklet 2651. Overhung load ratings, dimension tables, selection instructions and cutaway views of double and triple reduction units are included. 16 pages. Link-Belt Co.

—Circle ITEM 421

Variable Speed Pulleys

Instructions for selecting and installing variable speed pulley systems for industrial power take-off are found in illustrated brochure. Proven formulas and tables are included, along with specifications. Equipment Engineering Co.

—Circle ITEM 422

Industrial Engines

Specifications, power curves, design features and dimensional drawings for the Ford 239 cu in. displacement V-8 cylinder industrial engines are found in illustrated bulletin TIE 9-7003. Brake horsepower ranges from 50 to 97 at from 1400 to 2800 rpm. 4 pages. Ford Motor Co., Tractor & Industrial Engine Div.

—Circle ITEM 423

Vacuum Forming of Plastics

"Concepts that Count in Vacuum Forming" is illustrated folder that describes vacuum forming of plastics, shows examples and evaluates company's equipment and facilities. Available formable materials are covered. 4 pages. Nordic Plastics Co.

—Circle ITEM 424

Pressure Vessel Steels

"Comparison of Carbon and Alloy Steels for Pressure Vessels" is a booklet that simplifies plate steel selection by graphically comparing the cost of specific steel against service requirements of pressure and temperature. Extensive technical data are included. 12 pages. Lukens Steel Co.

—Circle ITEM 425

Gravity Conveyors

Galvanized Rapistan steel gravity conveyors, offered at same price as painted steel channel units, are described in illustrated bulletin GAL-55. The steel coating will not flake or chip. Conveyor applications are outlined. 4 pages. Rapids-Standard Co.

—Circle ITEM 426

High Speed Scale

High speed commercial weighing is possible with the model 51 Exact Weight scale, described on data sheet. It is offered in 4-oz, 100-gram and 1500-grain capacities. Specifications and design details are given. 1 page. Exact Weight Scale Co.

—Circle ITEM 427

Aluminum Extrusions

Information on two 8000-ton extrusion presses, their capacities and products they can produce, is found in illustrated booklet. Extrusion design suggestions are covered. Hollow and solid shapes up to 17 in. wide and 85 ft long can be made. Heavy press extrusions booklet has 24 pages. Kaiser Aluminum & Chemical Sales, Inc.

—Circle ITEM 428

Stainless Steel Wire

What Can You Do with Precision Stainless Steel Wire? is question asked and answered in illustrated form FWM. It describes and illustrates various applications for this product. Covered are filters, cabling, shielding, shock absorbers, instrument springs and flexible tubing. 4 pages. Fort Wayne Metals, Inc.

—Circle ITEM 429

Working High Speed Steels

Expanded edition of the Blue Technical Data Sheet on "Working of Tool and High Speed Steels" features 17 charts giving cutting tool angles, cutting speeds, temperature ranges and guides. Heat treating, design, machinability and other subjects are also treated. 16 pages. Allegheny Ludlum Steel Corp.

—Circle ITEM 430

Solid Film Lubrication

Latest technical advances of Electrofilm solid film lubrication are detailed in illustrated brochure B-3. It inhibits fretting corrosion, prevents galling and seizing, lubricates under high loads and speeds, and functions well from −100 to 700° F. Electrofilm, Inc.

—Circle ITEM 431

Precision Spindles

Design and application data on a complete line of Super Precision spindles for grinding, boring, drilling, milling and work heads are presented in illustrated catalog No. 20. Types covered include belt drive, motorized and high frequency. Both standard and custom-built spindles are available. 48 pages. Standard Electrical Tool Co.

—Circle ITEM 432

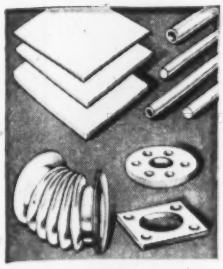
Limit Switches

Seven models, 19 contact arrangements and 150 lever styles are but a few of the details of Loxswitch machine tool limit switches given in illustrated catalog 955. Design features which contribute to long trouble-free life of switch are explained. 12 pages. R. B. Denison Mfg. Co.

—Circle ITEM 433

TO THE MEN WHO DESIGN AND BUILD BETTER PRODUCTS...

Heres How JOHN CRANE CAN HELP YOU!



CHEMLON PRODUCTS

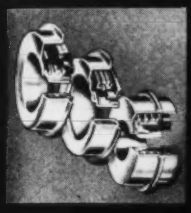
"John Crane" Chemlon offers the remarkable properties of DuPont Teflon in basic forms and parts of all types for practically all applications. These range from basic forms, such as sheet, rod, tubing and tape, to machined, molded or extruded parts fabricated to specification.

Use "John Crane" Chemlon Products for: handling all difficult acids, corrosives and solvents at temperatures from −120°F. to +500°F. . . . electronic insulation where high dielectric strength, high arc resistance and low power factor are vital . . . non-stick applications.

MECHANICAL PACKINGS

"John Crane" maintains nationwide service and engineering to supply mechanical packings for every industrial requirement. Packings are available in all sizes, styles and materials to suit individual requirements and conditions.

Use "John Crane" Packings for: handling all types of liquids and vapors from water and steam to the most destructive acids, alkalis and solvents . . . temperatures to 1200°F. and over . . . to meet your pressure requirements.



MECHANICAL SEALS

"John Crane" engineers seals of all types and sizes for every application. Construction features include positive drive, self-alignment to compensate for normal shaft run out and precision lapped sealing faces.

Use "John Crane" Seals for: all types of rotating shaft applications such as water, steam, boiler feed water, petroleum products and hot oil, acids, corrosives and solvents . . . over a wide temperature and pressure range.

LAPMASTER Lapping Machines

Here's a machine capable of generating surface flatness to less than one light band—finishes to 2 RMS consistantly in short or high production runs . . . a machine that has given many designers an opportunity to obtain product improvement and performance at lower cost.

Use the "John Crane" Lapmaster for: precision lapping of parts for adding machines, engines, transmissions, cameras and projectors, tool and die equipment, quartz crystals, etc. . . . materials such as monel, steel, stellite, brass, aluminum, glass, carbon, plastics and ceramics.

PLASTIC LEAD SEAL* AND THRED-GARD

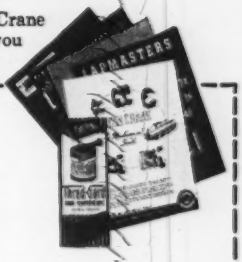
"John Crane"* PLS easy-to-apply plastic sealing compound provides positive protection against leakers under service applications up to 550°F., 6000 psi. It lasts for the life of the connection, yet permits easy disassembly at any time because it never hardens.

Use "John Crane" PLS for: handling water, steam, gas, petroleum products, chemicals and refrigerants...on pipe joints, threaded connections, plugs, screwed fittings, flanges and gaskets.

"John Crane" Thred-Gard high temperature compound lubricates and prevents seizing and galling of threaded surfaces and fittings under extreme heat conditions up to 1200°F. It permits connections to be drawn to a greater degree of tightness without undue strain.

Use "John Crane" Thred-Gard for: preventing damage to studs on exhaust manifolds, cylinder heads, heat exchangers, coolers, condensers . . . flange bolts on pumps, valves, autoclaves, reactors, kettles . . . die casting dies and die casting machine fittings.

GET FULL DETAILS on how John Crane can help you. Check the information you want, fill out and mail in this coupon.



- ☐ John Crane Teflon Products
- ☐ John Crane Mechanical Packings
- ☐ John Crane Mechanical Seals
- ☐ Lapmaster Lapping Machines
- ☐ John Crane PLS
- ☐ John Crane Thred-Gard

Name_____

Title_____

Company_____

Address_____

Crane Packing Company, 6425 Oakton St., Morton Grove, Ill., (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*

JOHN CRANE

CRANE PACKING COMPANY

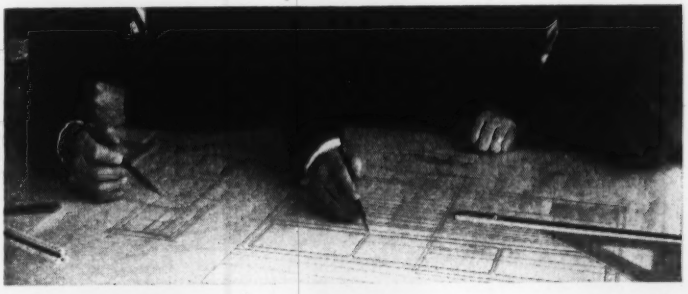
38 YEARS INDUSTRIAL PROGRESS

OFFICES IN PRINCIPAL CITIES

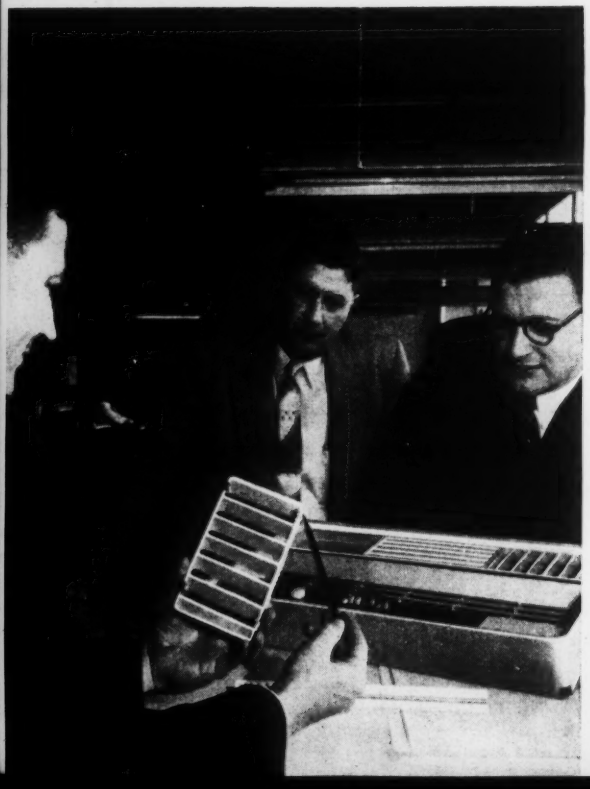
MONSANTO

Today's industrial designers face a dual challenge in the race to outdistance competition. Their products must be more pleasing in appearance, more efficient in performance. Many of these designers are working closely with plastics engineers in the custom molding industry to achieve both goals simultaneously. Read how one of America's leading manufacturers of air conditioning units improved sales in a fiercely contested market by utilizing the unique properties offered by plastic materials.

New housings of Lustrex Styrene plastic are building business for Fresh'nd-Aire



DESIGN OBJECTIVES. In creating a new line of air conditioning units, the management of the Fresh'nd-Aire Company, division of the Cory Corporation, Chicago, required an interior housing with many advanced features. The new housing had to have sleek decorating styling to make it an outstandingly handsome piece of furniture. It had to incorporate tight-fitting removable parts. It also had to be produced at reasonable cost.

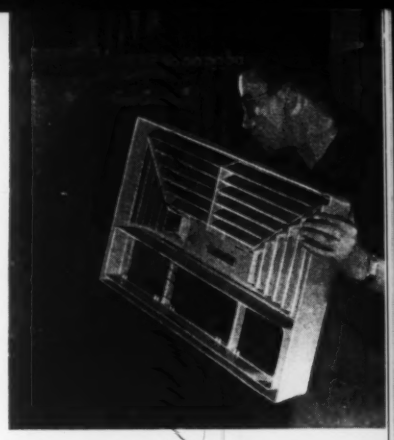


MATERIAL SPECIFICATION. Careful testing by Fresh'nd-Aire engineers proved that Lustrex high impact styrene offered the most desirable characteristics. A styrene housing could be economically produced with an attractive, soft-lustered, surface-to-surface coloring in the specified shade. This eliminated six costly painting and cementing operations. Injection molding techniques for high impact styrene freed designers from the restrictions of metal die-stamping machines. Modern smooth-flowing lines could be obtained. There was no danger of rust or corrosion deteriorating the housing. Furthermore, Lustrex high impact styrene provided a strong base for rivets, bolts and other anchoring devices. This tough Monsanto styrene also demonstrated its ability to hold critical dimensions. Parts like reversible vents and a front cover accessory panel could be removed and replaced repeatedly without the hazard of bending out of snug fit.

PRODUCTION ENGINEERING. General American Transportation Corporation, Chicago, was commissioned to supply the styrene housing for Fresh'nd-Aire. Every design requirement was satisfactorily met by molding the component of Monsanto Lustrex Hi-Test 88, a rubber-modified high-impact styrene. The part is produced in a hydraulic 1500-ton press and contains 40 ounces of the Monsanto styrene material.

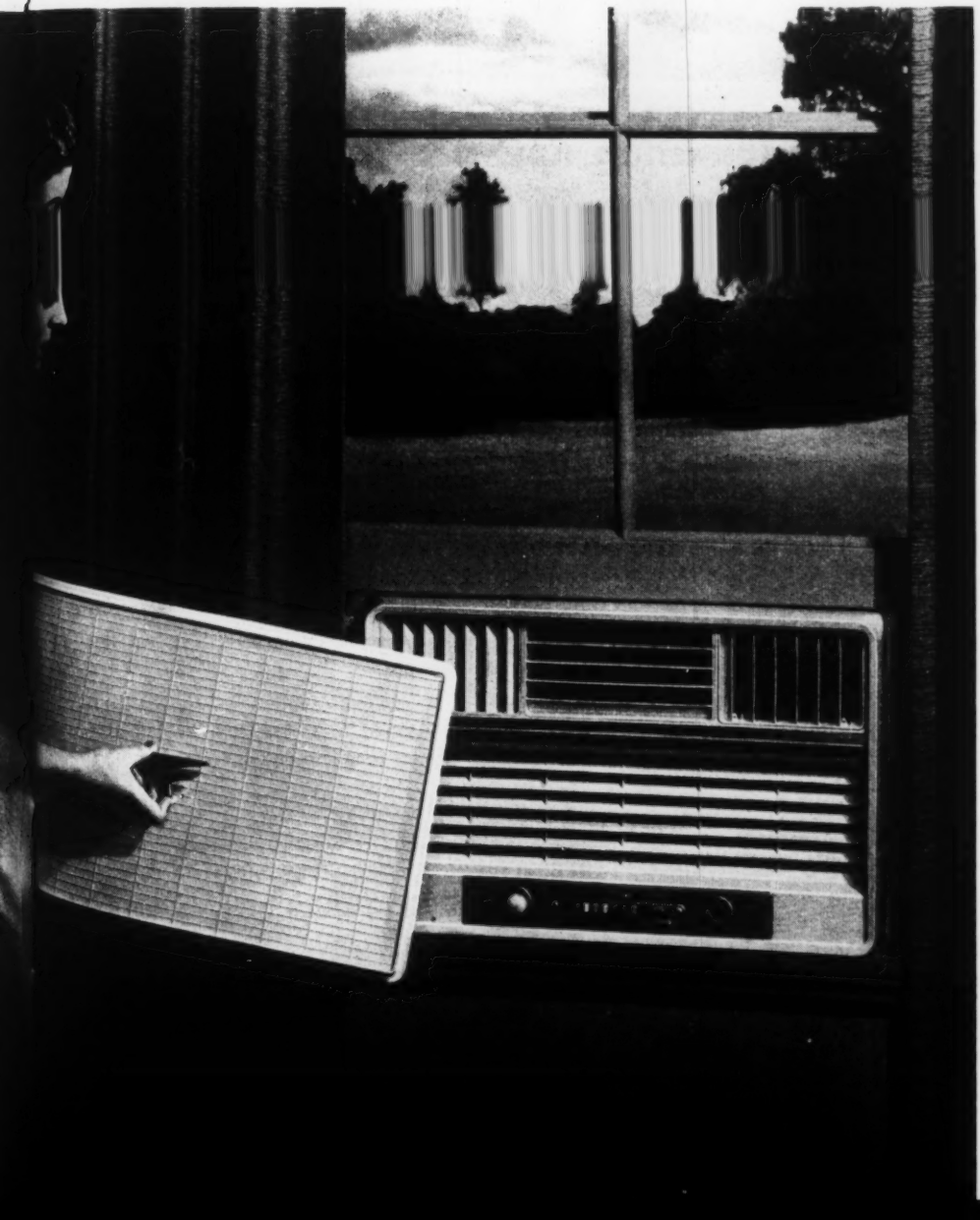
THE FINISHED PRODUCT. The new Fresh'nd-Aire unit has earned the hearty approval of both trade and public. Sales officials agree the change to styrene components has improved the marketability of the line. The interior housing and exclusive "Style-Gard" accessory panel have added vital style interest to the unit—and improved its performance. A 300% sales increase over last year is anticipated for the 1956 season.

This is one of hundreds of design and production problems which have been solved by utilizing the facilities of the plastics custom molding industry. These 20th Century craftsmen are available to manufacturers designing for greater efficiency and lower costs. As a major supplier of plastic resins, Monsanto is in a position to introduce you to custom molders who will put their skills to work for you. If you are considering a design change for your product line, be sure to investigate plastics. Write to Monsanto Chemical Company, Industrial Applications Dept., Room 606, Springfield 2, Mass.



Investigate the Monsanto completely-balanced line of styrene plastic compounds developed for particular applications and sold under the trade name...

LUSTREX® Styrene Plastic



MONSANTO®

Automation now provides laboratory precision at mass production costs!

LINEAR'S exclusive ROTO-MOLD process has introduced *automation* to the packing industry: Perfectly uniform "O" Rings can now be delivered quickly—in any quantity!

Here are the facts:

- LINEAR ROTO-MOLD "O" Rings are made with laboratory precision in single cavity molds under individually controlled pressure. Molding dies are automatically brought into microscopic alignment.
- Every ROTO-MOLD "O" Ring is perfectly circular in cross section, with no transverse or other seams. You get precise uniformity without trimming or grinding.
- The ROTO-MOLD process is fully automatic. Contamination or imperfections due to human error are eliminated.

LINEAR ROTO-MOLD "O" Rings are available now, in a variety of sizes and compounds—including the latest polymers developed to resist destructive fluids at elevated temperatures. Write, phone or wire for complete details.

While in Philadelphia for the **DESIGN ENGINEERING SHOW** call on us with your sealing problems

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR Inc., State Rd. & Levick St., Philadelphia 35, Pa.

—ITEM 619—

For More Information Circle Item Number on Yellow Card—page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Bearing Mounts

incorporate eccentric locks and lubricant seals

These new pillow-block and flange-style bearing mounts for antifriction bearings provide positive lubricant sealing, spherical outer rings, relubrication fittings and eccentric locks. Pillow block, type SYH-X, has reduced center height to permit use where space is limited. FY-X flange mounting is for application where bearing housing must be positioned at right angles

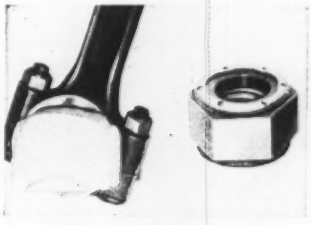
to the shaft. Interchangeable with mounts of similar design, they are available in a range of load capacities. **SKF Industries Inc.,** Front St. and Erie Ave., Philadelphia 32, Pa.

—Circle ITEM 461

Self-Locking Nut

has reduced dimensions and high load capacity

Designed for application where minimum wrench clearance exists, such as on the connecting rod shown, this type TEE2032 washer-face hex nut has overall dimensions no greater than those of a 10-32 nut. It is C-1137 steel, plain finished, and is available in ¼-28 thread size. Load capacity is almost 20 per cent higher than



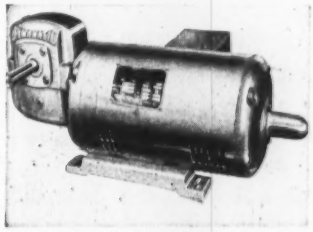
standard ¼-28 nuts; axial tensile strength reaches 5379 lb, minimum. Self-locking action is provided by the red nylon collar, which is not affected by immersion in oil at crankcase temperatures. **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J.

—Circle ITEM 462

Adjustable-Speed Drive

available with integral brake or gear reducer

This adjustable-speed drive unit, in fractional-horsepower sizes, can now be supplied with an integral electromagnetic brake or an integral speed reducer (shown). Brake torque ratings are 18 or 36 lb-in.;



speed ratios on the gear reducers run from 5:1 to 100:1, depending on the drive power rating. Construction of the drive unit incorporates a constant-speed induction motor, an eddy-current coupling and an electronic control, which stabilizes speed to ±2 per cent at any point in the operating range. All drives have continuous constant-torque rating through a 25:1 speed adjustment range. **Eaton Mfg. Co.,** Dynamatic Div., Kenosha, Wis.

—Circle ITEM 463

Rigid Plastic Pipe

combines chemical resistance and high bursting strength

Riviclor is a rigid, high-strength, unplasticized polyvinyl chloride pipe with impact strength as high as 2.5 (Izod). It resists the action of chemicals, electrolytic corrosion,

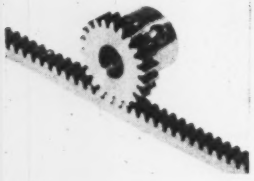
fungus, bacteria, etc., and remains tough and nonbrittle at subzero temperatures. Inside surfaces are glossy smooth, minimizing head losses at high flow rates. Pipe and fittings are available in sizes from ½ to 2 in., standard or extra heavy. Working pressures are 490 psi for the ½-in. size, 255 psi for the 2 in. pipe (extra-heavy construction). **American Hard Rubber Co.,** 93 Worth St., New York 13, N. Y.

—Circle ITEM 464

Fine-Pitch Racks

are cut to AGMA Precision 1 tolerances

Type AG precision fine pitch racks are designed for use where rotary motion must be converted to



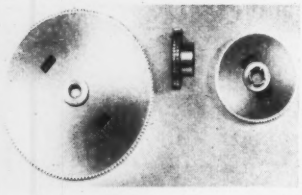
straight line motion with minimum loss. These racks are cut to AGMA Precision 1 tolerances and are available in 48, 64, 72 and 96 pitch, 20 deg pressure angle, to run with PIC type G precision spur gears. Racks are stainless steel (clear passivated) and 24ST aluminum, chromic acid anodized. **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

—Circle ITEM 465

Antibacklash Gears

with clamp-type or solid hubs

Pitch diameters of these antibacklash gears range from 1 to 2 in.; pressure angles are 14½ or 20 deg. Diametral pitches run from 48 through 120. Gear blanks are 24ST aluminum (Alodined or



anodized), and hubs are 303 stainless steel, clamp or solid type. Bore sizes available are 0.125, 0.1875 and 0.250-in. **Dynamic Gear Co. Inc.**, 20 Merrick Rd., Amityville, N. Y.

—Circle ITEM 466

Hex Nuts

can be wrenched internally or externally

Lightweight, stamped hex nuts are applicable for aircraft, guided missile and electronic equipment. Internal wrench adapter is intended for use in limited space where there is insufficient clearance for external wrenching. The nuts can be applied closer to adjoining structure, and spotface diameters and flange widths are reduced. They are approved under applicable Air Force-Navy specifications and conform to Air Force-Navy standard drawings AN363, AN364 and AN365. Sizes from No. 4-40 through No. 5/16-24 are available. **Kaynar Co.**, 830 E. Sixteenth St., Los Angeles 21, Calif.

—Circle ITEM 467

Shaded-Pole Motors

rated 1/15 through 1/10 hp

Addition to line of shaded-pole, totally enclosed motors is this model, which is rated at 1/15 through 1/10 hp. Sealed, recirculating lubrication system reduces service requirements in hard-to-reach locations. Diameter of No. 39 frame is 5½ in. **General Electric Co.**, Specialty Component Motor Dept., 1 River Rd., Schenectady 5, N. Y.

—Circle ITEM 468

Tube Fitting

for temperatures from −65 to 212 F

Type 7000 Series Ermeto high-pressure SAE flareless, straight-thread hydraulic tube fitting accommodates minimum close coupling, positive seal and ease of assembly. Phosphate finish is resistant to nonflammable hydraulic fluids and petroleum base fluids. The finish reduces torque needed to preset or reset sleeve. Designed for use with the new SAE O-ring boss, the fitting withstands high operating pressures without the use of backup rings and operates at temperatures from −65 to 212 F. The fitting is available in 31 styles in sizes from ⅛ to 2 in. Typical applications include use in machine tools, hydraulic presses,

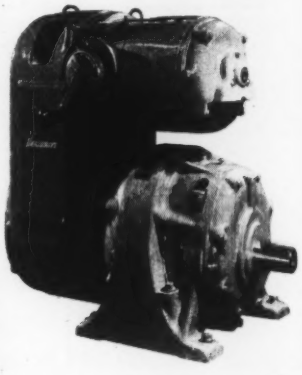
construction and excavating equipment, fluid power controlled materials handling equipment, drilling and mining equipment. **Weatherhead Co.**, Ft. Wayne Div., 128 W. Washington Blvd., Ft. Wayne, Ind.

—Circle ITEM 469

Variable-Speed Motor

for low-speed, high-torque service

Takeoff shaft and motor are on the same side in this variable-speed, internally geared Varidrive motor assembly. Application is in low-speed, high-torque service where weight distribution and limited installation space present problems. Designated types VEV-1-GD (double reduction) and VEV-1-GM (triple reduction), the units come in vertical or horizontal styles and in ratings to 5 hp. Motors can be specified drip-proof, totally-enclosed or explosion-proof. Mechanical, remote or automatic



controls are available. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

—Circle ITEM 470

Automatic Transmission

provides two-speed shift for small gasoline engines

Operated by action of the accelerator, this automatic two-speed transmission is designed for small

EATON

DYNAMATIC®

SINGLE PACKAGE

FRACTIONAL HP AJUSTO-SPEDE® DRIVES

Provide Stepless Adjustable Speed from an AC Power Source

STANDARD

WITH FRICTION BRAKE

WITH SPEED REDUCER

Sizes and Types for Hundreds of Industrial Applications

Dynamatic Ajusto-Spede® Drives, part of a family of diversified eddy-current equipment, provide an economical solution to many adjustable speed drive problems.

The Fractional Horsepower Ajusto-Spede, a single package design, combines an AC constant speed induction motor, eddy-current coupling, and electronic control. Standard modifications provide for the addition of electrically operated fail safe friction brakes, or speed reducers with numerous gear reduction ratios.

Fractional Horsepower Ajusto-Spede Drive power is taken directly from 115/220 volt, single phase or 220/440 volt, 3 phase lines. Sizes are ¼, ⅓, ½ and ¾ horsepower at 1600 RPM; ½, ¾ and 1 horsepower at 3200 RPM.

Friction brakes for quick stopping or fast cycling operation are furnished in two capacities—1½ and 3 pounds feet of torque.

Gear reductions with 10 ratios between 5-to-1 and 100-to-1 are supplied with 1600 RPM Ajusto-Spedes.

Ajusto-Spede® Advantages

- ★ **Constant torque speed range: 25 to 1 with either 1600 RPM or 3200 RPM Ajusto-Spedes.**
- ★ **Control accuracy: 2 per cent of top speed at any point within the speed range.**
- ★ **Minimum wiring to power line.**
- ★ **Remote "one knob" control operation up to 100 feet.**
- ★ **Rugged plug-in type integral one-tube electronic control.**
- ★ **Permanently sealed grease-packed bearings.**

For more detailed information, write for your free copy of the Dynamatic Fractional Horsepower Ajusto-Spede Bulletin, FAS-5.

EATON MANUFACTURING COMPANY

DYNAMATIC DIVISION

3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

—ITEM 620—

ENGINEERS & DRAFTSMEN

Electric Boat designed and built the Nautilus, the world's first atomic powered submarine. Soon the Seawolf will join the Nautilus at sea. And EB has contracts for 3 more nuclear powered craft! Start now in the nuclear propulsion field—enjoy the challenge as well as the well-known Electric Boat benefits, educational program and pay. Draftsmen are currently working a 6-day week.

immediate openings for:

MECHANICAL ENGINEERS

1. **FLUID & NUCLEAR SYSTEMS**—*to engineer nuclear plant design of pressurized water reactor systems, develop heat transfer and flow calculations. Minimum 2 years power or chemical plant experience. Fluid system analysis experience desirable.*
2. **POWER PLANT SYSTEMS**—*to engineer steam propulsion plant systems, prepare system diagrams and descriptions, perform heat balance and thermodynamic calculations. Instrumentation system experience desirable.*
3. **PIPE STRESS**—*experienced in practical and theoretical applications of power plant piping. Routine calculating not required. Experience required in analysis of complex piping arrangements.*
4. **HYDRAULIC**—*3 to 5 years experience in hydraulic systems up to 3000 PSI, including selection and sizing of components.*
5. *3 to 5 years experience in component design including stress analysis, linkage and gear trains. Component selection and specification experience desirable.*
6. *3 to 5 years experience in vibration and dynamic stress analysis on rotating components.*

DRAFTSMEN

PIPING—*2 to 3 years experience in design of air, water, ventilation, hydraulic or fuel oil systems. Marine or chemical process experience preferred.*

MECHANICAL—*2 to 3 years experience in design of hydraulic components, gear and link mechanisms, castings, weldments and special valves.*

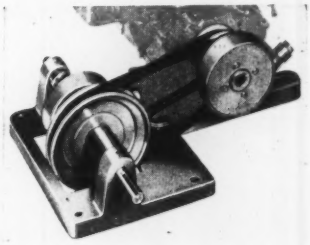
STRUCTURAL—*For design and detail of structures and foundations associated with nuclear powered submarines.*

Find out now all the other plusses Electric Boat offers you. Send a complete resume, including salary requirements, to Peter Carpenter. Convenient interviews will be arranged.

ELECTRIC BOAT
Division of GENERAL DYNAMICS CORPORATION
GROTON • CONNECTICUT
(near New London on the Connecticut shore)

—ITEM 621—

New Parts



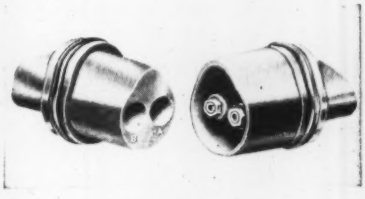
gasoline engine powered vehicles, such as personnel carriers, garden and riding tractors, motor scooters, etc. Shift from neutral to low and from low to high is governed by engine speed. Speed ratio in low is 50 per cent of engine speed; high ratio is 80 per cent of engine speed. Unit is adaptable to engines rated to 3 hp at 3600 rpm. Larger capacities or special ratios can be furnished on request. **Triune Products Co.**, 23350 Edward St., Dearborn 7, Mich.

—Circle ITEM 471

High-Voltage Connectors

are pressure tight

Developed for altitude applications where electrical leads must be pressure tight, these high-voltage connectors leak less than 1 cu in. of air per hr when subjected to 30 psi pressure differentials. They have either two or three contacts designed for AN24 shells. Inserts



are mineral-filled Melamine, and contacts—which are nonrotating—are removable for wiring. **Dejur-Amsco Corp.**, Electronic Sales Div., 45-01 Northern Blvd., Long Island City, N. Y.

—Circle ITEM 472

Solenoid Valve

has only two moving parts

Two-way direct solenoid controlled valve utilizes in-line construction so that all control parts can be removed easily in one assembly, without disturbing piping. Primar-

main valve seat for fire plug

Sand-cast pegs bent easily, causing improper fire plug operation. Full line pressure could not be maintained. Machining often uncovered blow-holes causing rejects. Switched to brass forging for higher strength, dense structure, closer tolerances, reduced over-all costs.

multi-port valve body

Porous sand-cast part caused non-detectable leaks in air and fluid system tests. Switch to fine-grained brass forging stopped trouble. Rejections, scrap, costs all reduced. Closer tolerances and better appearance achieved by using brass forging.

base for TV signal transmission

Porosity and blow-holes in sand-cast part caused "high standing wave," or loss of power feeding into TV transmitting tower through base on end of cable. This required tearing down whole assembly at considerable cost. Switch to dense, strong forging eliminated rejects and power leakage.

water meter lid and register box

Lid converted from sand casting to brass forging. Register box from sand casting to pressure die casting. Weight reduced greatly on both — thus lowering costs. Closer tolerances after change eliminated costly machining on the box.

Vital Change

from sand castings to brass forgings

Titan

METAL MANUFACTURING COMPANY

Bellefonte, Pa. Offices and Agencies in Principal Cities

Titan brass forgings are more easily drilled, tapped, broached and milled than are sand castings. Fewer machining rejects result. Forgings are hot-pressed quickly, are denser, tougher and stronger. Moreover, brass forgings have a smooth beauty and warmth not obtainable in sand castings. Scrap is reduced. Some machining operations necessary on sand castings are actually eliminated by switching to accurate-dimensioned forgings. Getting down to brass tacks, what this means to you is lower costs and a better product by switching to Titan hot-pressed brass forgings.

Send us a sample, drawing, and production quantities of sand-cast assembly parts you now use. We'll quote you on changing to brass forgings.

If you want more data on Titan brass forgings, send coupon below:

Dept. T-76
Titan Metal Manufacturing Co., Bellefonte, Pa.
Gentlemen:

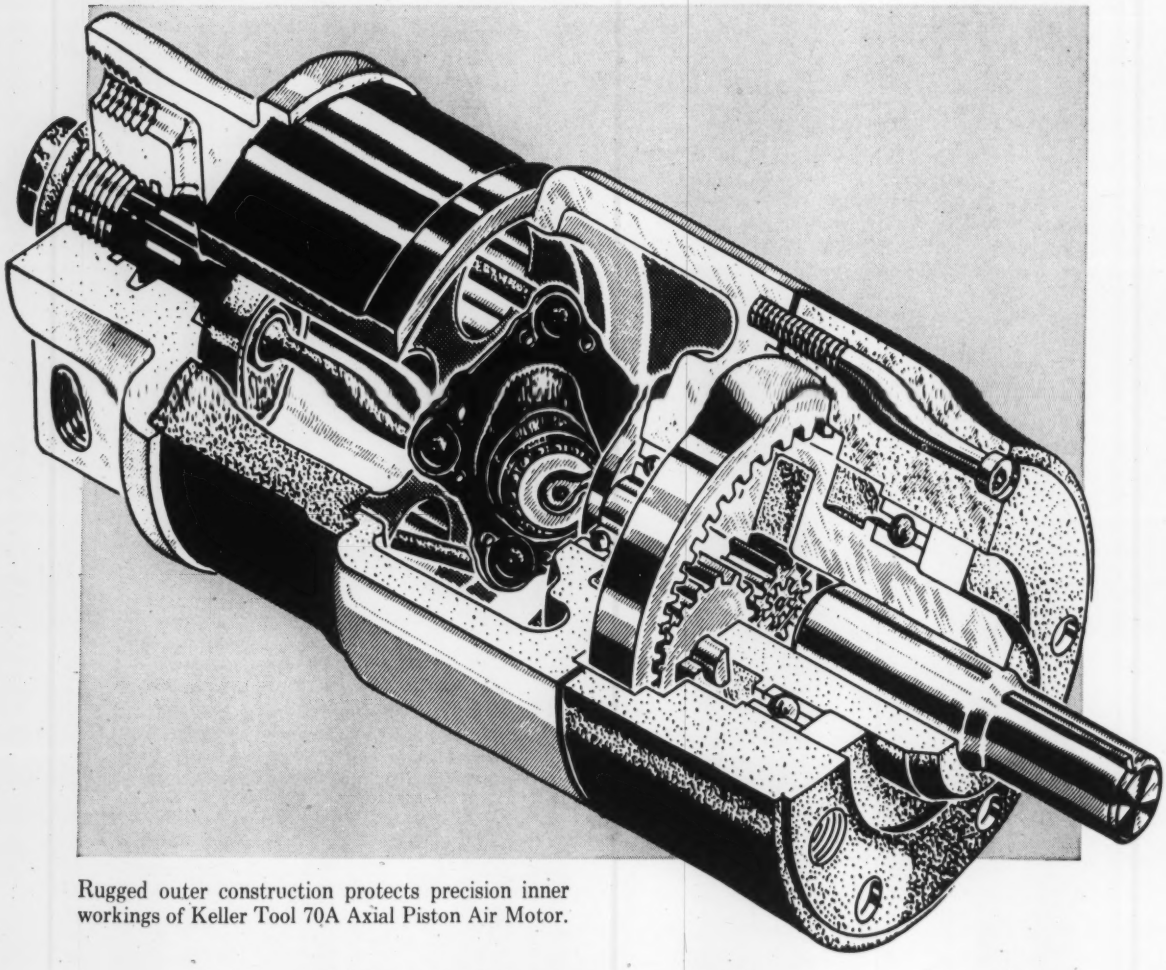
- ☐ Will send sand-cast part and details for you to quote as brass forging
- ☐ Please send further data on Titan brass forgings
- ☐ Have Titan representative call

Name_____ Title_____

Company_____

Address_____ City & State_____

Gardner-Denver . . . Serving the World's Basic Industries



Rugged outer construction protects precision inner workings of Keller Tool 70A Axial Piston Air Motor.

Inside information tells why
Keller Tool air motor stars on tough assignments

Compact Design—Axial piston motor provides high torque and horsepower characteristics within compact dimensions.
No external spindle support needed—Generous size ball bearings safely accommodate heavy overhung load on spindle.
Face mounting—Three tapped holes assure positive mount without strapping. You position air connections for clean piping design.
Defy dust and corrosion—Enclosed construction permits use in contaminated environment. Motor withstands exposure to heat.

Operating characteristics—Instantaneous starts and stops . . . infinitely variable speed in either direction . . . non-sparking . . . cannot burn out when stalled . . . high torque at low speed . . . consistent stall torque, variable through air pressure regulation . . . efficient operation at high or low air pressure.

Send for Bulletin 70 today! It gives detailed specifications, dimensions and performance charts on 12 models of the Keller Tool Axial Piston Air Motor ranging from 0.6 to 2.7 h.p.

Other air motor favorites . . .

Keller Tool 1 h.p. Rotary Vane Air Motors. Bulletin 71.

Gardner-Denver Five-Cylinder Radial Air Motors from 3 to 16 h.p. Bulletin AM-1.

GARDNER-DENVER

KELLER TOOL division, Grand Haven, Michigan

THE QUALITY LEADER IN COMPRESSORS, PUMPS, ROCK DRILLS AND AIR TOOLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

—ITEM 623—

For More Information Circle Item Number on Yellow Card—page 19

ily for ac applications (pressure or vacuum), this normally-closed valve is available in standard pipe sizes from ¼ through 2 in. Its two moving parts assure positive, high-speed action with short plunger travel. Completely noncorrosive, it can be controlled by a relay or microswitch, can be

mounted in any position and operated continuously without harm to the valve or the solenoid. **Airmatic Valve Inc.**, 7317 Associate Ave., Cleveland 9, O.

—Circle ITEM 473

Teflon Tape

is 0.0005-in. thick

This Teflon tape has many applications in capacitors, transformers, and for wrapped and sintered wires and cables. Thickness of 0.0005-in. provides adequate dielectric strength with less Teflon area. The tape is supplied in continuous rolls with a minimum of splices. Widths from ½ to 12 in. are wrapped to 6 in. OD on 1⅛ in. diameter spools. **Enflo Corp.**, Route 38 at Airport Circle, Pennsauken, N. J.

—Circle ITEM 474

Line Filters

for valves handling small flows

Micron-Filter brass and stainless steel line filters have a replaceable bronze filter element which filters out particles larger than 5 to 12 mu. The units are used in conjunction with valves handling small flows where foreign dust or particles in the fluid stream tend to clog the throat, change the effec-

A call to any one of our seven warehouses will get you speedy service on your order . . . whether it's for *alloy steel bars, billets or forgings,* in any size, shape or treatment you need.

All seven warehouses are located in principal industrial areas. Each is modern and well-stocked, and staffed by expert metallurgists.

Call now if you need our own HY-TEN steels — "the standard steels of tomorrow", or standard AISI or SAE grades.

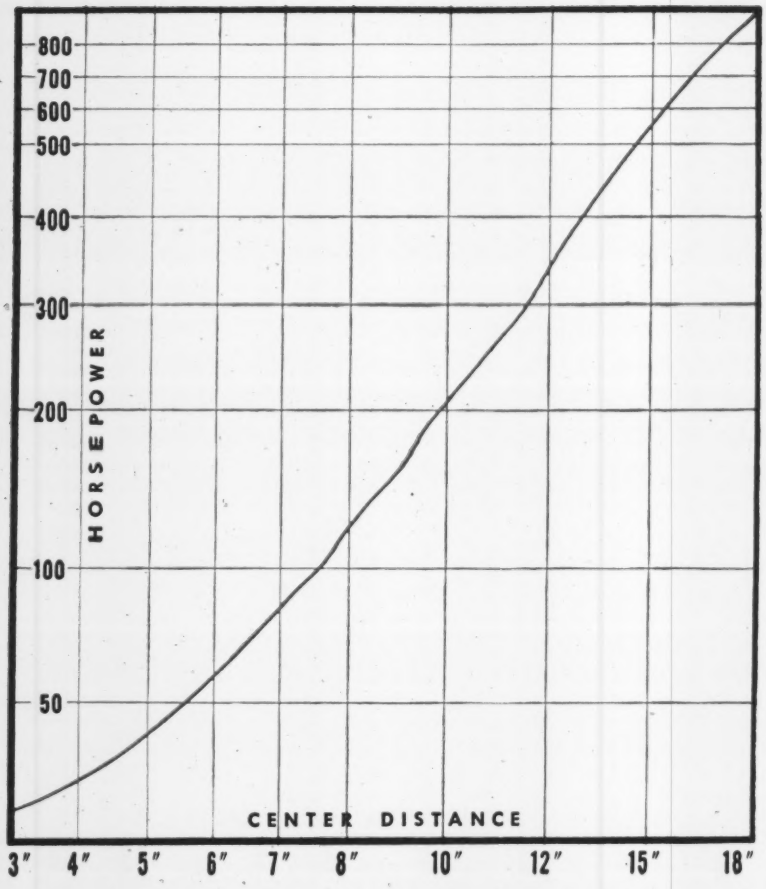
Or write for *free* copies of Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

In Canada: Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.

133 Sidney Street, Cambridge 39, Massachusetts

—ITEM 624—



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

. . . because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

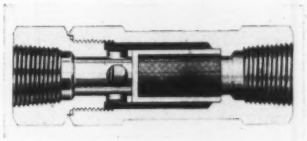
Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact over a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 625—

New Parts



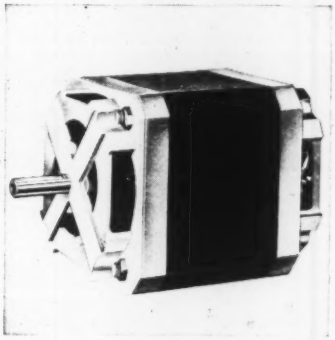
tive opening or obstruct full closing of the valve. They are available in female pipe sizes of ⅛ and ¼-in. NPT. **Hoke Inc.**, 191 S. Dean St., Englewood, N. J.

—Circle ITEM 475

Subfractional Motor

has output rating of 1/75-hp

Sub-fractional straight motor, designated VKM-14, has a 60-cycle, 115 v input. Motor speed is 3200 rpm, based on 3.5 MFD capacitor; output rating, 1/75-hp. Permissible duty, 20 per cent duty cycle, 3 minutes maximum continuous runing time. Wiring is either 3 wire unidirectional or 4 wire reversing



type. Motor shaft measures 5/16-in. maximum OD in any length. Weight of the unit is 2 lb 6 oz. **Janette Electric Mfg. Co.**, Small Motor Div., Lehigh and Main St., Morton Grove, Ill.

—Circle ITEM 476

Retaining Rings

in variety of materials and finishes

Available in three series for internal and external applications, these retaining rings are supplied in carbon spring steel, stainless steel, phosphor bronze and beryllium copper. Finishes include oil dip, black oxide, nickel plating, Parkolac-black, and cadmium or zinc plating. Internal series 3000 rings are manufactured in 37 sizes

Double A's WIDE LINE OF HYDRAULIC CONTROL VALVES

Offers you...

EXACT VALVE ACTION REQUIRED WITH FEWER VALVES AT LOWER COST

- ★ **PIPE SIZES: ¼" THRU 2"**
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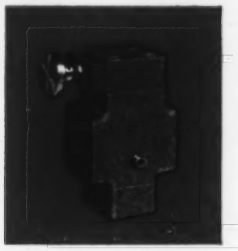
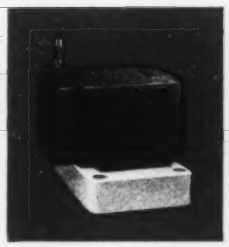
- ★ **MOUNTING TYPES: CONNECTIONS IN BODY, SUB-PLATE MOUNTING, FLANGED CONNECTIONS**



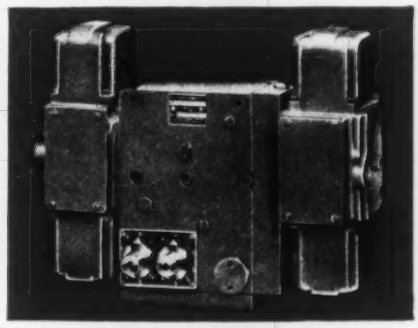
RELIEF VALVES

BY-PASS VALVES (for sequence and unloading applications)

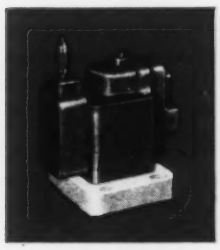
BY-PASS and CHECK VALVES (for counterbalance and sequence applications)



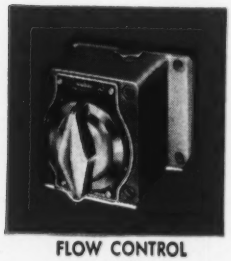
REDUCING VALVES



TRAVERSE and FEED CONTROL PANELS

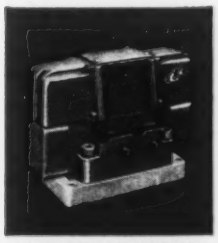


REDUCING and CHECK VALVES



FLOW CONTROL VALVES

DIRECT SOLENOID VALVES



SOLENOID CONTROLLED PILOT OPERATED VALVES

WRITE FOR NEW FULL LINE CATALOG
OR CONTACT YOUR LOCAL REPRESENTATIVE

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CALIFORNIA
The Rucker Co.
Oakland-Olympic 3-5221
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COLORADO
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Chicago-Portsmouth 7-4969

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Scott Equipment Company
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The Rucker Co., Seattle

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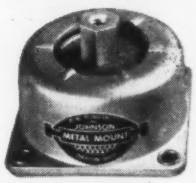
OUTSIDE CONTINENTAL U. S. CONTACT:
International Sales Division
New York Airbrake Company
New York, New York
Phone: Worth 4-3580

—ITEM 626—

(Advertisement)

USING BERYLLIUM COPPER TO DESIGN A VIBRATION MOUNT THAT HAS A DAMPING EFFICIENCY OF 95%



SOURCE: K. W. Johnson, former chief engineer of the Mechanical Section, Wright Air Development Center, and president of K. W. Johnson & Company, Dayton, Ohio

Objective:

To obtain an all-weather, all-altitude metal mount which will provide maximum damping and stability for electronic instruments in shock conditions up to 30 g, and in-flight vibration conditions through the range of 1-500 cps.

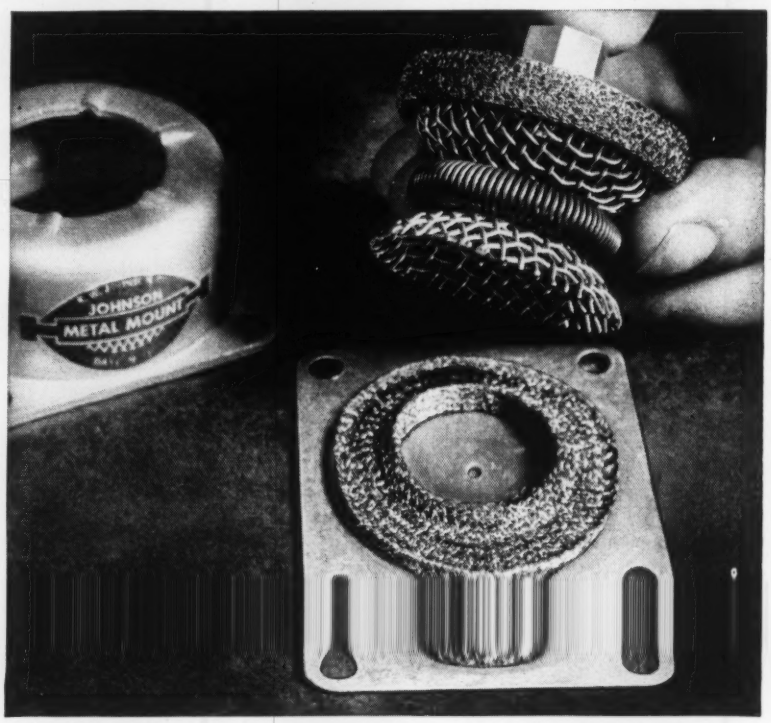
Metal Requirements:

In addition to the stringent load requirements, the metal used must pass test conditions of temperature differentials ranging from —65°C. to +200°C., high salt spray concentrations, extreme humidity, and long storage. It must have excellent fatigue life and metallic compatibility.

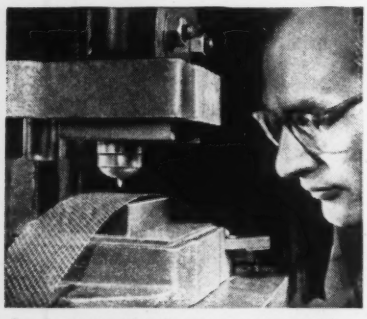
Procedure:

A convexed spring is fabricated of beryllium copper wire cloth, formed and cut on a punch press, then heat treated. Two of these discs are fastened together back-to-back with the convex surfaces facing each other. A circular coil spring is fitted around the assembly in the "V" made by the joining of the discs.

The concave-convex beryllium copper assembly absorbs the shock in a vertical and radial pattern. This spring alone would produce a bouncing action, causing the unit to move in uncontrolled prolonged cycling. To regulate this effect, the motion of the beryllium copper spring is resisted by the friction of the coil spring against the convex surface of the concave-convex spring. It cushions the downward action as it expands, and contracts to level the upward surge. The end result is a double damping system where the coil spring moderates the concave-convex system, and, at the same time, is damped by it. Consequently, magnification at resonance is controlled on the order of 1.5.



The mount uses a double reacting spring arrangement—a beryllium copper concave-convex spring and a circular coil spring provide a damping efficiency up to 95%.



Forming and cutting the concave-convex spring from "BERYLCO" brand #25 wire cloth.

Test Results:

In the 50-hour salt test, stainless steel cloth failed completely—the stainless convexed springs could be broken apart and disintegrated by handling. A shift was made to "BERYLCO" #25 beryllium copper alloy to obtain a cloth which had superior spring characteristics over stainless, and gave much greater fatigue life. The beryllium copper spring holds up without failure or setting tendencies, and it is unaffected by a salt atmosphere. It has proven to be over 200% better from a life and service standpoint.

Many metals and alloys cannot be used together in applications of this type because they are inducive to an electrolytic action. Localized corrosion resulting from a coupling of dissimilar metals does not occur in this mount, because beryllium copper is compatible with the other alloys which are used.

Summary

"Beryllium copper is the heart of our vibration control unit," asserts K. W. Johnson, president of the K. W. Johnson Company. "It has given us the qualities of high strength, resistance to temperature extremes and severe shock, increased fatigue life, and eliminated the danger of corrosion. Without it, we could not have passed the service qualification test."

A technical bulletin (#33), with specific details on the design and use of beryllium copper in the Johnson Metal Mounts, is available on request without charge. Write to

THE BERYLLIUM CORPORATION • Reading, Pennsylvania

"BERYLCO" Brand Beryllium Copper Is Shelf-Stocked by Leading Warehouse Distributors

Export Department: Reading, Pennsylvania • Cable Address "BERYLCO"

—ITEM 627—

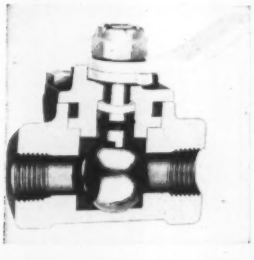
for housings measuring ¼ to 2 in. diam. External rings, series 3100, come in 47 sizes for shafts from ⅛ to 2 in. diam. Rings meet National Aircraft Standards. **Industrial Retaining Ring Co.,** 8 W. Sidney Ave., Mount Vernon 33, N. Y.

—Circle ITEM 477

Ball Valve

seals flow tightly in either direction

Top-entry, twin-seal construction of this ball valve permits maintenance without removal of the valve from the line; flow shutoff is positive for either flow direction. Minimum turbulence is introduced by the circular opening in the valve. Choice of valve bodies in naval bronze, aluminum bronze and



aluminum permits use with wide variety of fluids. Seats are Buna-N, neoprene, natural rubber, Hypalon or Teflon. **Worcester Valve Co. Inc.,** 16 Parker St., Worcester, Mass.

—Circle ITEM 478

Casing Clamps

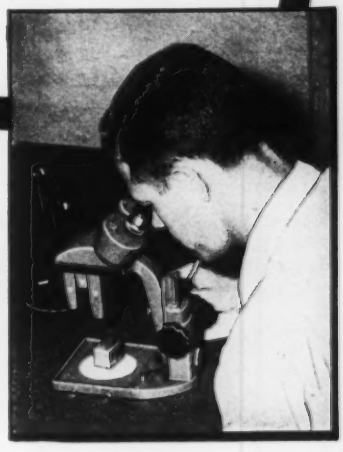
for flexible casings from 3/16 to 7/16-in. diam

Suited for use at flexible control-line ends or at intermediate positions, this clamp will accommodate casing diameters from 3/16 to 7/16-in. The clamp is mounted

(*Continued on Page* 166)

RESEARCH AT WORK FOR YOU

CHIEF SANDUSKY



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Many concerns are discovering strong, uniform, closely grained Sandusky centrifugal castings are essential to applications requiring maximum strength and extreme resistance to heat, corrosion, and abrasion. Chief Sandusky continuous research is ever expanding the range of these uses.

This versatility and quality results from constant research and testing in our modern firm and independent laboratories. Vast foundry and field experience also assists in supplying the proper castings for you.

Excellent machining facilities for drilling, turning and boring are available.

Call or write Sandusky, the leading source of ferrous and non-ferrous centrifugal castings. ALWAYS SPECIFY CHIEF SANDUSKY.

C. M. Lovsted & Co., Seattle, Wash. • Tynes Bros., Birmingham, Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

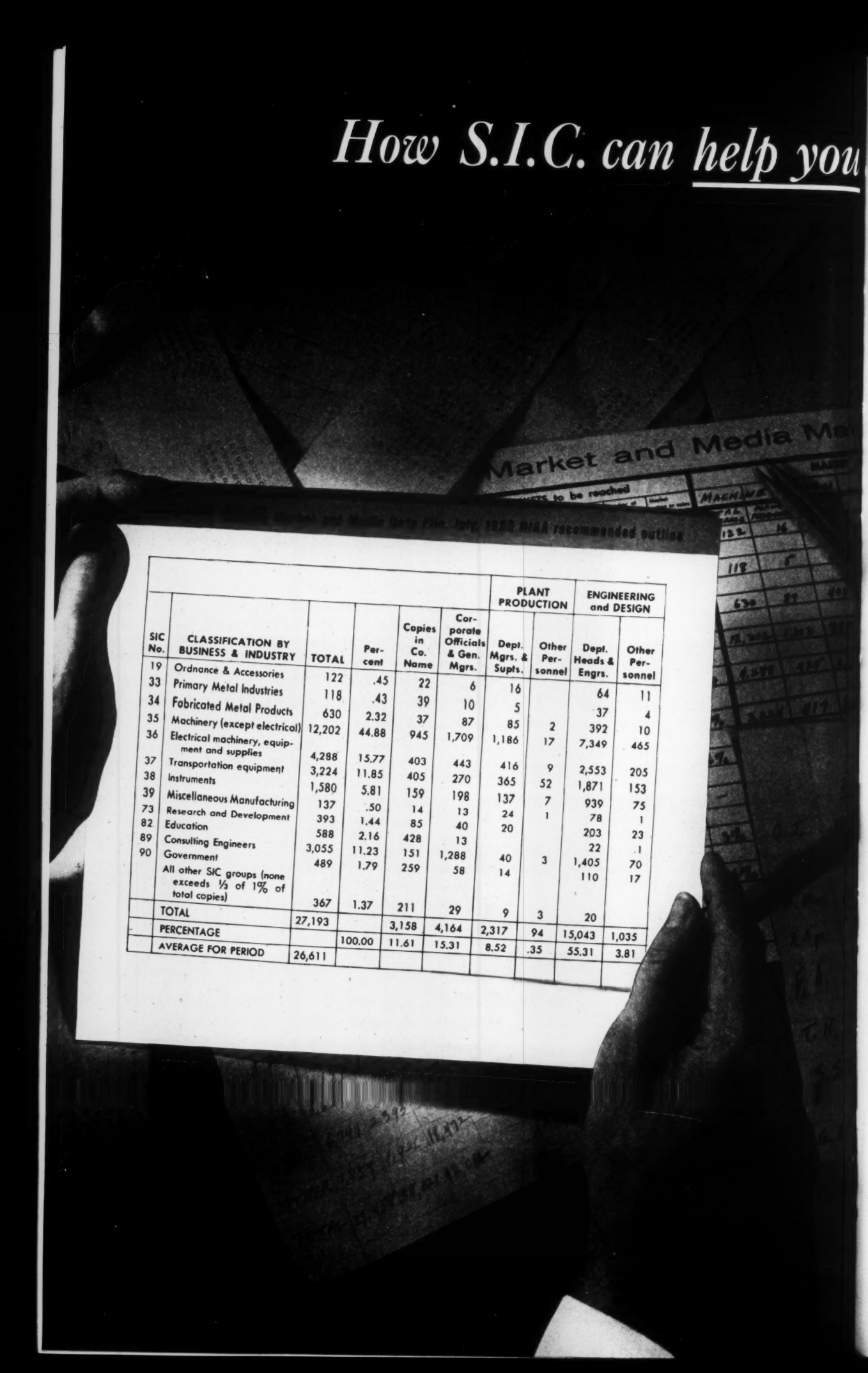
Chief SANDUSKY CENTRIFUGAL CASTINGS

FERROUS AND NON-FERROUS

SANDUSKY FOUNDRY AND MACHINE CO., Sandusky, Ohio

—ITEM 628—

How S.I.C. can help you



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						Dept. Mgrs. & Supts.	Other Per-sonnel	Dept. Heads & Engrs.	Other Per-sonnel
19	Ordnance & Accessories	122	.45	22	6	16		64	11
33	Primary Metal Industries	118	.43	39	10	5		37	4
34	Fabricated Metal Products	630	2.32	37	87	85	2	392	10
35	Machinery (except electrical)	12,202	44.88	945	1,709	1,186	17	7,349	465
36	Electrical machinery, equip-ment and supplies	4,288	15.77	403	443	416	9	2,553	205
37	Transportation equipment	3,224	11.85	405	270	365	52	1,871	153
38	Instruments	1,580	5.81	159	198	137	7	939	75
39	Miscellaneous Manufacturing	137	.50	14	13	24	1	78	1
73	Research and Development	393	1.44	85	40	20		203	23
82	Education	588	2.16	428	13			22	.1
89	Consulting Engineers	3,055	11.23	151	1,288	40	3	1,405	70
90	Government	489	1.79	259	58	14		110	17
	All other SIC groups (none exceeds ⅓ of 1% of total copies)	367	1.37	211	29	9	3	20	
	TOTAL	27,193		3,158	4,164	2,317	94	15,043	1,035
	PERCENTAGE		100.00	11.61	15.31	8.52	.35	55.31	3.81
	AVERAGE FOR PERIOD	26,611							

take the confusion out of circulation figures

Circulation figures by themselves can get mighty confusing!

But there's a very useful tool developed by Uncle Sam, and used extensively by Penton, that takes a lot of the confusion and frustration out of Media Selection.

The Standard Industrial Classification System, better known as S.I.C., is the basis on which Penton publications report circulation and market statistics. This helps you do a more effective job of selecting media . . . and do it faster.

It enables you to check circulation figures by uniform industry breakdowns.

It pleases sales managers because many of them now classify their own sales in this way. They like the quick comparisons which they can make on Penton publications—a column of circulation figures showing total coverage of each S.I.C. product category. Along side of it is a count of the number of establishments. From the Penton Market Data Files you can determine readily the number of the worthwhile establishments you're reaching.

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YOU'LL DO BETTER
WITH UNITCASTINGS!

We make no *special* claims to produce miracles with cast steel. Like competitive foundries, problems are similar . . equipment may differ slightly . . it's the *end performance* of the casting that counts!

A little *extra* surveillance in process pays off quality-wise. Customers receive better, cleaner castings . . meeting accepted specifications . . and end up with a lower *finishing* cost. Less scrap . . less re-work . and less lost production time amounts to more than incidentals!

Standard carbon and low alloy steel castings, up to 150,000 psi tensile . . whatever your requirements, specify Unitcastings!

UNITCAST CORPORATION • Toledo 9, Ohio
In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

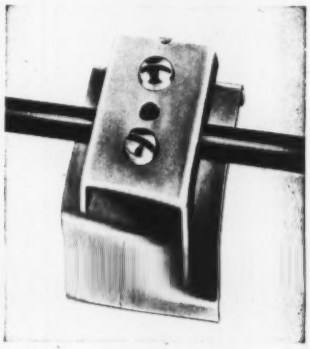
Unitcast

QUALITY STEEL CASTINGS

New Parts

(*Continued from Page* 163)

with two screws and will not swivel from its installed position. Construction is cadmium-plated steel, and the clamps are supplied either completely assembled or as separate stampings. They are not



recommended for use as tubing or electrical cable clamps. **Arens Controls Inc.**, 2017 Greenleaf St., Evanston, Ill.

—Circle ITEM 479

Miniature Thermostat

is factory preset for appliance control

Series 201 Klixon miniature thermostat is designed for low-cost application in units such as table appliances, percolators, heating appliances and electronic equipment. It has factory preset temperature settings from 80 to 300 F, positive snap-action operation, and is enclosed for protection against dirt and lint. The disk can be exposed for faster thermal response where

necessary. For resistive loads only, the thermostat is rated at 10 amp 110 v ac for 6000 operating cycles, 5 amp 240 v ac for 50,000 cycles. **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

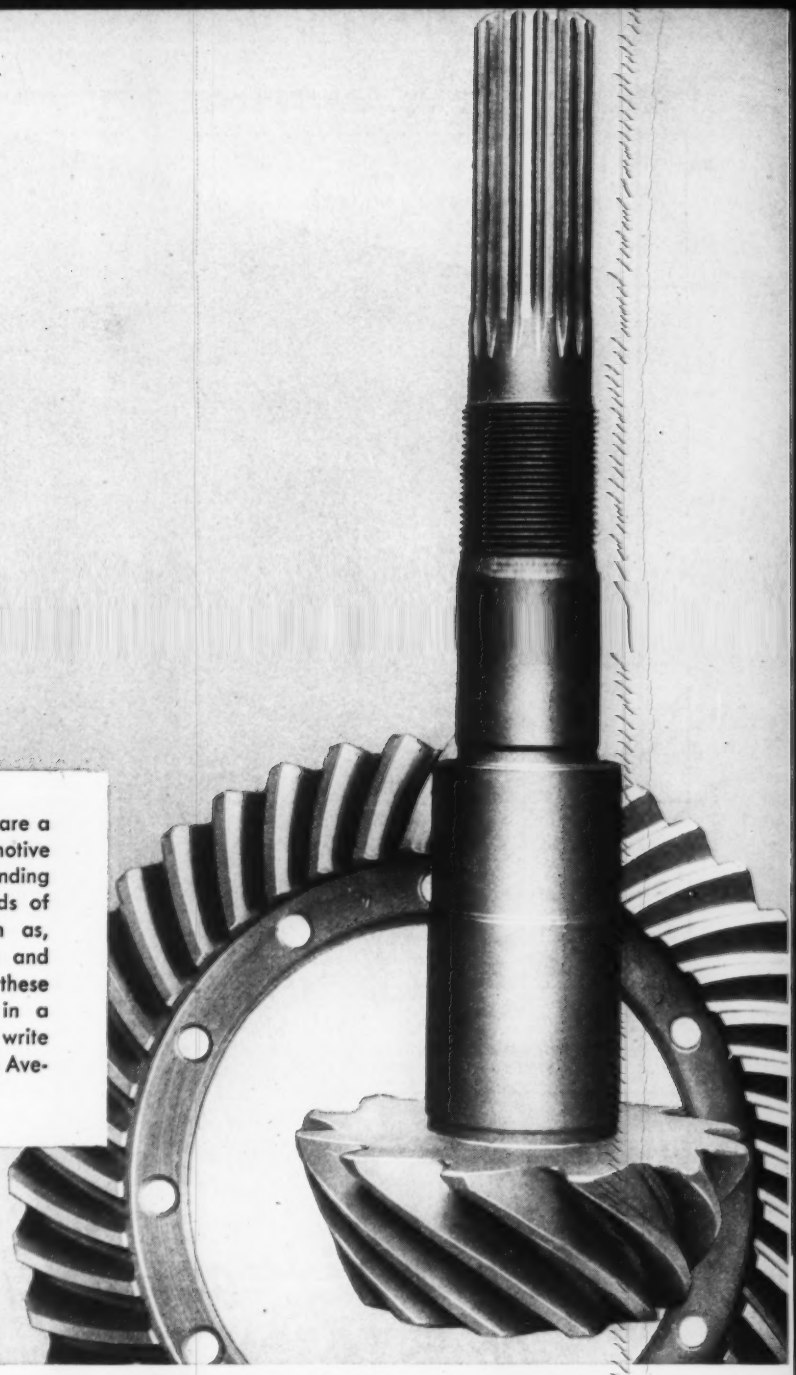
—Circle ITEM 480

Lubricator

distributes fine oil fog

Micro-Fog lubricating unit automatically creates fine oil fog which is uniformly distributed through piping systems to multiple lubrica-

"IT'S BETTER IF IT CONTAINS MOLY"



Moly carburizing steels with 0.5% Mo are a natural for components like this automotive ring-gear and pinion. They have outstanding properties that suit them to the demands of gearing and similar applications, such as, superior case hardness, low distortion and good machinability. Many features of these new carburizing steels are discussed in a recent technical article. For a reprint, write Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y., Dept. 11.

Molybdenum Carburizing Steels

MOLYBDENUM OFFERS THE ECONOMICAL KEY TO PERFORMANCE

Over the years, molybdenum carburizing steels have proved their merits in scores of applications and at every level of production.

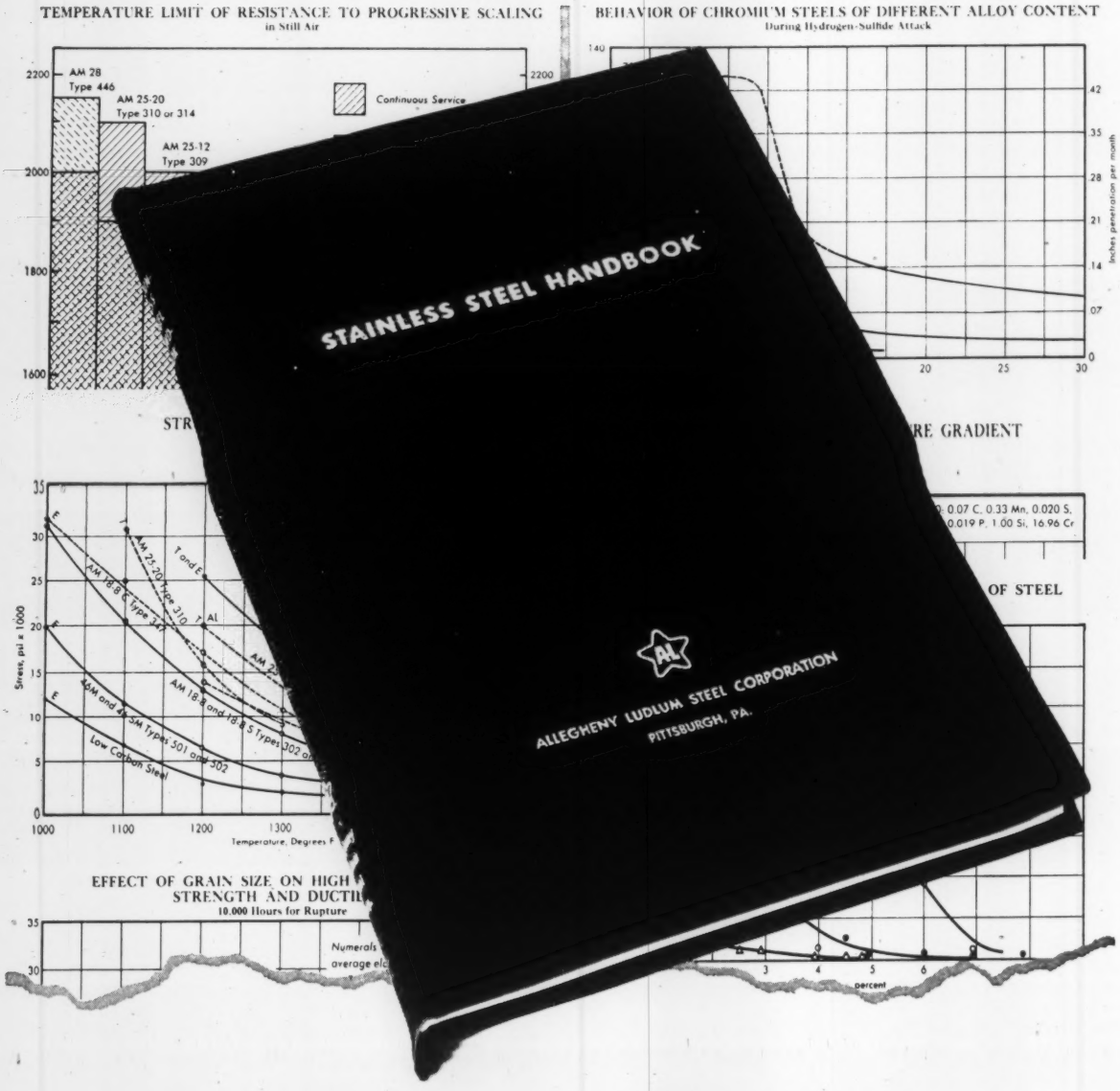
Design engineers know moly steels for their uniform hardenability, toughness and wear resistance.

Production men know that moly steels are easy to heat treat, easy to machine.

Management knows that moly steels mean economy in fabrication, high performance in a wide range of end products.

Standard molybdenum carburizing steels are widely available. Higher moly analyses may be ordered in heat lots from a number of leading suppliers.

CLIMAX MOLYBDENUM



Here's 124 Pages of Valuable Data on STAINLESS STEEL

Stainless and heat resistant steel can usually be classed as a critical material, since it not only contains strategic alloys but is indispensable in many vital industrial and armament applications. It is always important, therefore, to make every pound go as far as possible.

The latest edition of our comprehensive 124-page, case-bound Stainless Steel Handbook is ready for distribution now. It will help you to select the right stainless steel and to use it properly. Comprehensive listings of analysis, properties and characteristics of each type will guide you in specifying grades that will do your job most efficiently. Clear, concise fabrication data will help you speed production and cut waste.

Your copy of the Stainless Steel Handbook will be sent—*without charge*—upon request. Our only stipulation: please make your request upon your company letterhead. ● Write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

ADDRESS DEPT. MD-771

For Stainless Steel in ALL Forms—call

Allegheny Ludlum

AL® STAINLESS STEEL

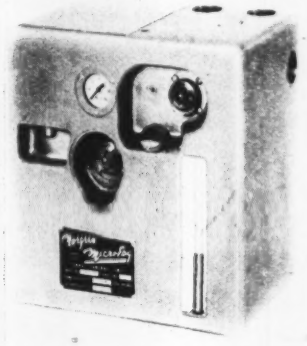
WSW 5185 B

Warehouse stocks carried by all Ryerson Steel plants

—ITEM 631—

For More Information Circle Item Number on Yellow Card—page 19

tion points. The unit can lubricate up to 1000 bearing-inches. Automatic drain filter removes abrasive and corrosive air line contaminants and drains collected liquids. A solenoid valve co-ordinates operation of the lubricator



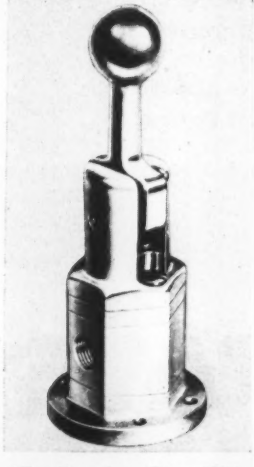
with the operation of the machine. The lubricator measures 12 x 11 x 9 in. It contains all controls and 2-gal oil reservoir which provides oil for 12 hr lubrication at maximum output. **C. A. Norgren Co.**, 3499 S. Elati, Englewood, Colo.

—Circle ITEM 481

Pilot Valves

come in five different styles

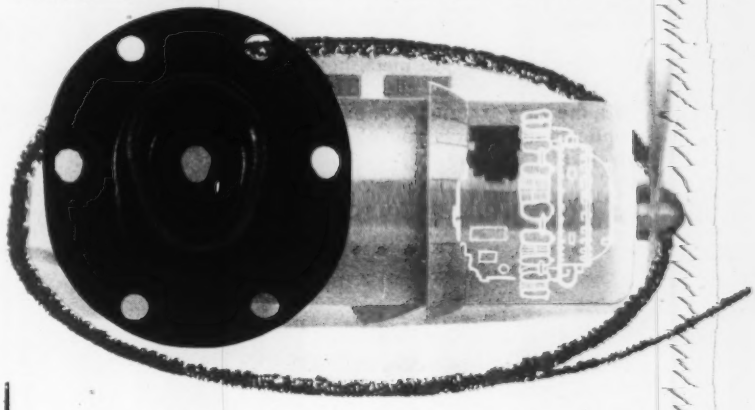
Line of compact, light-weight pilot valves includes hand, foot, palm-button, cam and solenoid operated types. Hand valve, shown here, is available in either locking or nonlocking models, and may be used singly or in series at working pressures to 150 psi. Palm-button type is especially suited for panel mounting. All valves are



(*Continued on Page* 172)

THE SHAPE OF THINGS IN MOLDED RUBBER!

MOLDED RUBBER & NYLON FABRIC INCREASES LIFE OF CARBURETOR DIAPHRAGM



APPLICATION:
Aircraft carburetor diaphragm molded for a nationally known aviation firm.

PROBLEM:
Nylon from customer's approved suppliers would not mold, therefore, holding up further development on diaphragm.

SOLUTION:
Acushnet chemists tested many types of nylon fabrics and in co-operation with the nylon supplier, used the results as a guide for a new fabric specification. New techniques were developed by the Acushnet laboratories to prevent pleating of the nylon. A special Acushnet compound molded to one side of the nylon proved successful in resisting the specified iso-octane and aromatic fuels. All dimensions were held to ± .003" without increasing the rejection rate. To further insure its life span, the bolt flange was molded of double coated neoprene on cotton which provided for greater strength and tear resistance.

Let Acushnet be responsible for producing your next molded rubber diaphragm. The complete facilities for creating special compounds and working with new fabrics assure precision diaphragms of all types and sizes.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

ACUSHNET PROCESS COMPANY
NEW BEDFORD, MASSACHUSETTS
... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING
Address all communications to 762 Belleville Ave., New Bedford, Mass.

—ITEM 632—

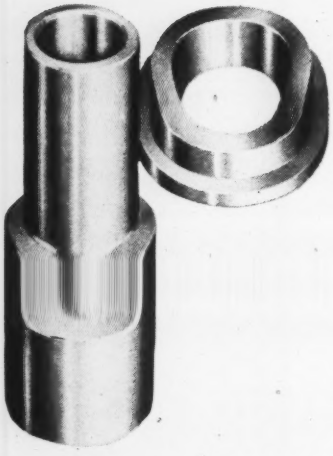
what are your bearing requirements?

A different demand . . . or set of demands . . . is made of bearings in every different product. Chief considerations may be: minimum noise level . . . corrosion resistance . . . low unit cost . . . wear resistance to oscillating or sliding motion . . . operation in presence of moisture . . . or others. When considering a sintered metal bearing for your product, it is essential that you obtain the correct alloy. The wide range of GRAMIX alloys, together with the long experience of our engineering staff in working with bearing applications, assures you of getting the best possible bearing for your product.

THERE IS A GRAMIX®

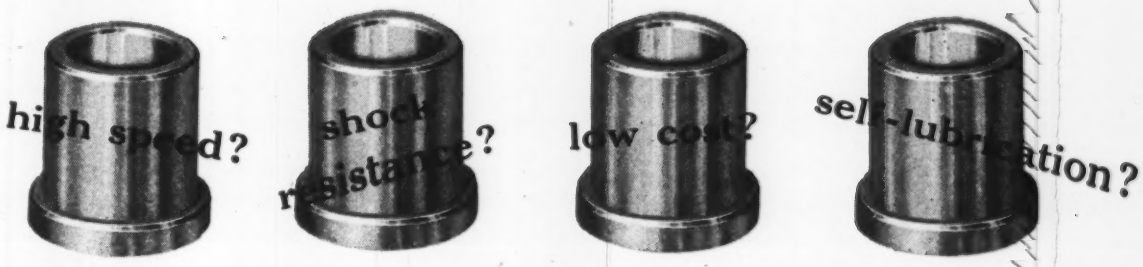
(A PRODUCT OF POWDER METALLURGY)

FOR YOUR

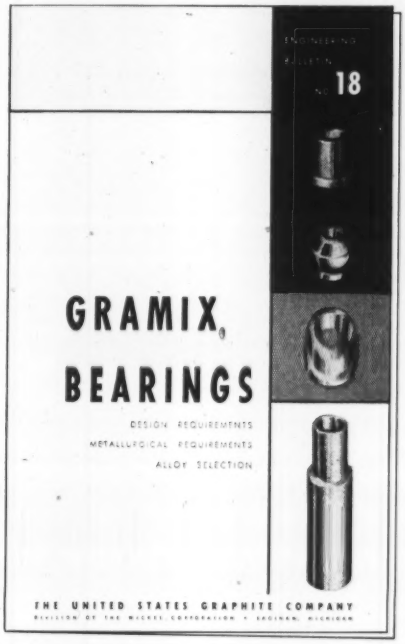


Certainly, there is such a thing as a "general purpose" sintered bearing alloy . . . GRAMIX Grade 81 fills this role, and does it well. But there are also applications that demand special alloys, designed to do a specific job better. There is a wide range of GRAMIX alloys to meet every individual design consideration. Properties of these alloys vary widely: tensile strengths range from 8,600 psi to 25,000 psi . . . elongations from 1% to 10%! Operating characteristics also vary. For example, under conditions where there is minimum lubrication, GRAMIX Grade 183 (copper, tin, lead, nickel) is recommended. For heavy duty operation in a surplus of oil, GRAMIX Grade 307 (copper, tin, lead, carbon) is preferred. These few facts convey an idea of the wide design range of GRAMIX alloys. There is *one* that exactly fits your product . . .

THE UNITED STATES



BEARING ALLOY DESIGN REQUIREMENTS



ENGINEERING BULLETIN No. 18

A NEW GRAMIX ENGINEERING BULLETIN TO HELP THE PRODUCT DESIGNER IN SPECIFYING SINTERED BEARINGS

Product engineers who specify bearing materials will find Engineering Bulletin No. 18 of great help. It presents in concise form much of the knowledge we have accumulated since 1924, when GRAMIX was first produced. Design requirements, metallurgical considerations, and alloy selection are all discussed. A table of data on GRAMIX alloy composition and physical characteristics such as density, tensile strength, elongation, and radial crushing strength is included. The section devoted to selecting the right GRAMIX alloy to fit greatly differing product requirements is an ideally simplified guide to this complex subject. Write for your copy of Engineering Bulletin No. 18 today.

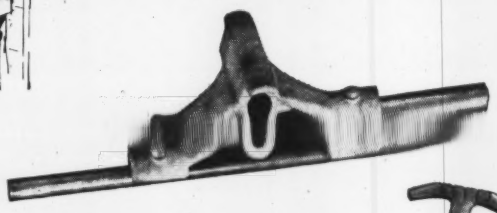
GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

—ITEM 633—

How About Malleable?

For tough service in heavy duty equipment, prominent manufacturer chooses malleable iron



Products that must be rugged and durable — like the important lawn maintenance machine below — are "naturals" for the application of malleable iron castings. This is an example of using malleable for a number of its advantages — sturdiness, uniformity, machinability, economy and appearance.

It pays you to find out how malleable foundry engineers can help you with ideas for cost-reducing and better design. Write to Malleable Founders' Society for copies of "Malleable Iron Facts" and name of your nearest malleable foundry.

Product and parts photos by courtesy of Toro Mfg. Corp., Minneapolis.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

—ITEM 634—

New Parts

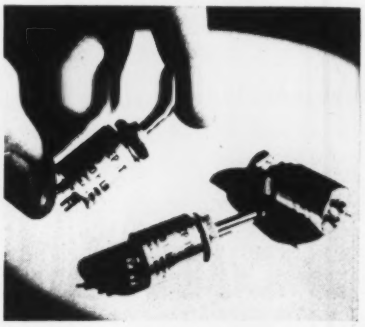
(*Continued from Page* 169)

furnished with a variety of mountings, according to user's specification. **Mechanical Air Controls Inc.,** 10030 Capital, Oak Park, Detroit 37, Mich.

—Circle ITEM 482

Subminiature Potentiometer

has resistance range of 200 to 250,000 ohms



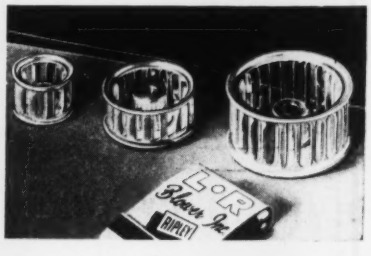
X-500 Acepot is a high temperature subminiature wire-wound potentiometer which operates in a temperature range of −55 to 150 C. One-piece anodized case gives maximum heat dissipation. Resistance range is 200 to 250,000 ohms, ±2 per cent; linearity is ±0.3 per cent. The potentiometer has high resolution, is ½-in. in size and weighs ¼-oz. It is available in threaded bushing, servo, flush-tapped hole or flange mountings in up to 6-gang units. It meets applicable portions of JAN and MIL-E-5272A specifications. **Ace Electronics Associates,** 103 Dover St., Somerville 44, Mass.

—Circle ITEM 483

Blower Wheels

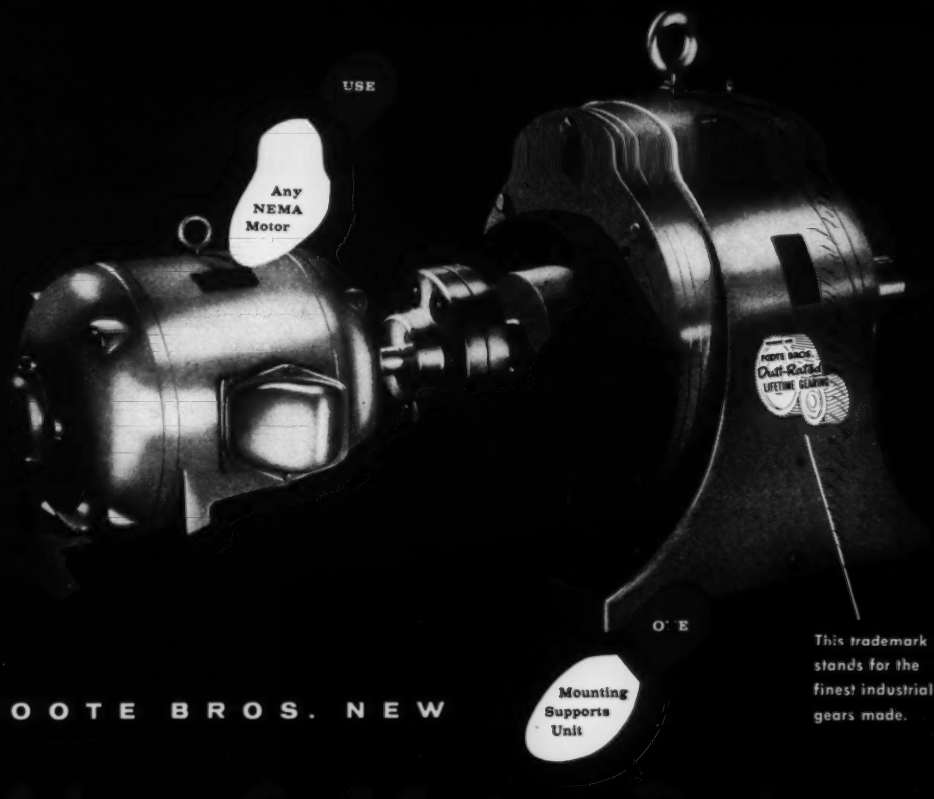
have rugged four-piece construction

Stocked in sizes from 1 to 3 26/32 in. diam, these L-R blower wheels can be furnished for clockwise or counterclockwise rotation. Material is plain or cadmium-plated steel or



Basic Idea

SOLVES MANY REDUCER MOUNTING PROBLEMS



FOOTE BROS. NEW

This trademark stands for the finest industrial gears made.

Line-O-Motor Drive

One base supports both speed reducer and motor in this simple, practical and foolproof mounting system . . . Now you can use standard N.E.M.A. motors and make change-overs in minutes—reducing both costly down-time and motor inventory.

Line-O-Power motorized drive solves many old problems . . . and opens new fields of advanced design for new applications. Available 1-75 H. P. for all Service Classes—Horizontal, Vertical, and Vertical Extended with Foot or Flange mounting—Double or Triple Reduction units available in Ratios from 5.06:1 to 238:1.

Better Power Transmission Through Better Gears

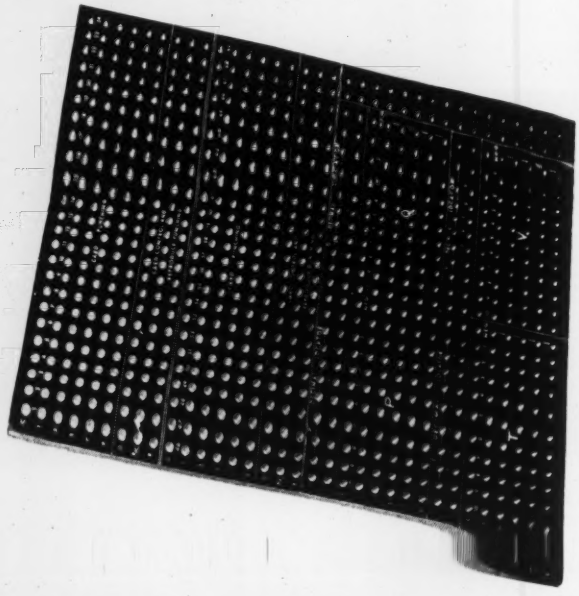
4545 S. WESTERN BLVD., CHICAGO 9, ILLINOIS

Department O

Write for your Line-O-Motor Catalog today

DESIGNING WITH DUREZ

ENDS 5 COSTLY OPERATIONS . . .



ON UNIVAC* COMPUTER PANELS

You can get components to meet exacting dimensional requirements with less machining and finishing than you may have thought possible. Here's an example of how a switch to Durez phenolic—the engineering plastic—saved a major portion of a component's cost.

This is an interchangeable plug terminal panel in Remington Rand's Univac "120" digital computer. Temperature and humidity affect Durez so little that 816 molded-in holes plus 34 slots and precision-fitting edges in each 8″ x 10″ panel conform to close tolerances. Secondary drilling, milling, and grinding are eliminated, while brushing and varnish-dipping are unnecessary.

Durez is noted for its electrical properties, impact strength, and resistance to heat, moisture, and chemical action. It molds readily in complex forms of varying section, and metal inserts can be molded in. All these properties come in many combinations. Let them help to solve your problems.

A HANDY NEW BOOKLET of technical information will be sent on request. Ask for "Facts on Phenolics."

DUREZ® *Phenolic Plastics that fit the job*

DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
506 Walck Road, North Tonawanda, N. Y.

HOOKER® CHEMICALS & PLASTICS

**Made by Remington Rand Univac® Division of Sperry Rand Corporation*

—ITEM 636—

New Parts

aluminum (plain or anodized). Wheel hubs come in a range of standard diameters and have one or two set screws. Construction is simple and rugged, only four pieces being employed in each wheel. **Ripley Co. Inc.**, Middletown, Conn.

—Circle ITEM 484

Plastic Bushing Caps

snap into bushings, hubs and conduit ends

These plastic bushing caps are easily installed with finger pressure, then assume their original shape and size to form a tight, protective seal. They snap into conduit bushings, insulated bushings, connector hubs and conduit ends,

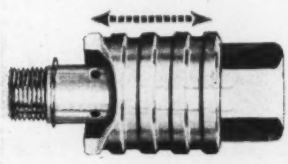
both rigid and EMT. The caps can be snapped into either metal or plastic bushings. They are available in all conduit sizes from ½ to 2 in. **Thomas & Betts Co.**, Butler St., Elizabeth, N. J.

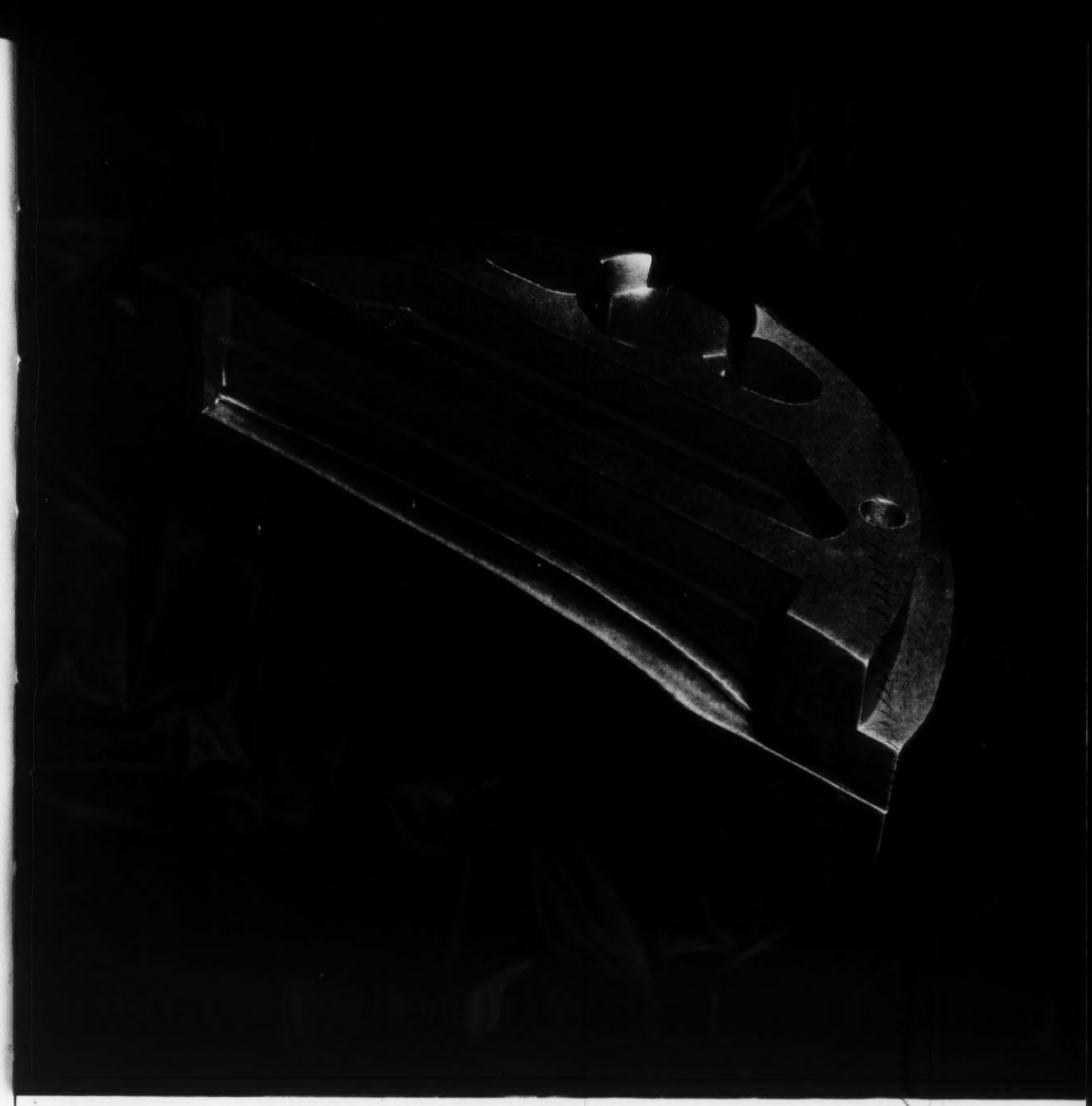
—Circle ITEM 485

Sleeve Valve

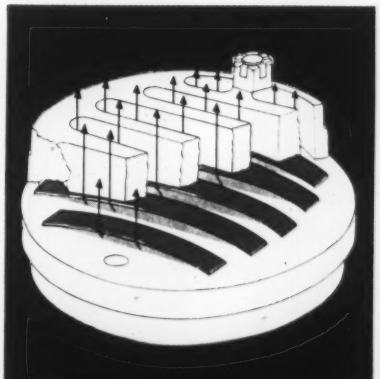
controls single-acting air cylinders

In-line sleeve-type valve which controls clamptype and similar single-acting air cylinders is actuated by a sliding sleeve. In downstream position, air flows through to the cylinder; in upstream position, inlet air is cut off and exhaust ports opened. An extension on the sleeve deflects exhaust air to protect the operator from air blast, blown chips or dirt. Available in ⅛, ¼ and ⅜-in. NPT sizes, the valve may be mounted directly





This compressor valve works with no impact for longer life, best efficiency



Stainless steel strips, in red, open the Feather Valve ports by rolling contact against the lower plate. There is no impact.

The Feather* Valve is the lightest, simplest, quietest compressor valve ever developed. Flexible strips of stainless steel open and close the valve ports with a gentle rolling contact. There is no destructive impact . . . even when the valve is operating as fast as forty times a second.

This lack of impact assures long life and negligible maintenance. The valve itself is all but indestructible. Absence of buffer plates and cushioning devices give it extreme simplicity.

The Feather Valve is quiet and reliable because of its lightness and tight contact seating. Valve action is very sharp. There is virtually no slip or back flow. As a result, you get minimum valve loss and use minimum power.

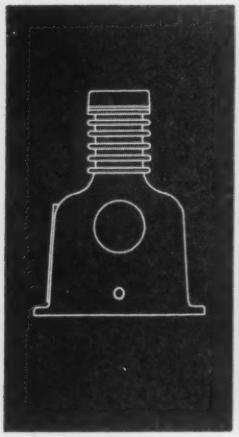
To get the utmost in performance, be sure you specify Worthington when you buy your next compressor. Worthington Corporation, Harrison, N. J. K.6.2

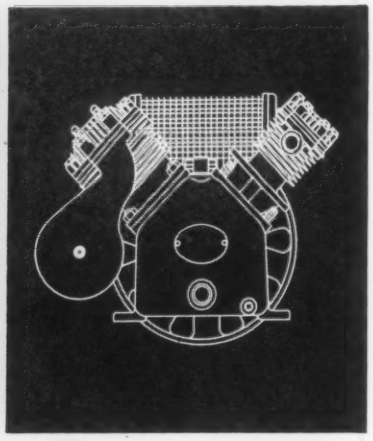
WORTHINGTON

*Reg. U. S. Pat. Off.

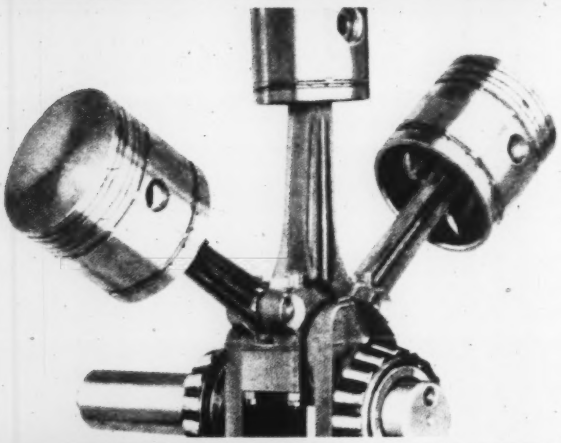
WHAT'S YOUR C.Q.?*

*COMPRESSOR QUOTIENT

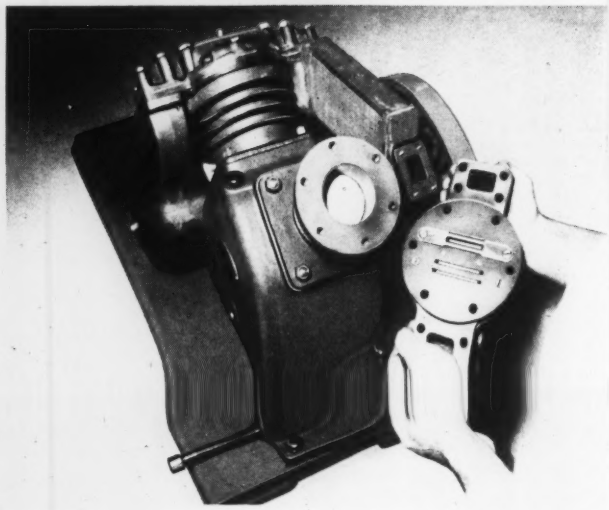




In-line or V-type—which is more efficient? In certain fields, this is a hotly debated subject. In compressors, however, most authorities agree that the V-type design provides better balance, smoother running, and better cooling. Besides building only the more efficient V-type design, Worthington casts each cylinder separately from the crankcase. Air thus flows completely around the isolated cylinders, increasing efficiency and saving power dollars.



Why is this connecting rod "aerodynamically" sound? This articulated connecting rod design assures smooth effortless operation, less bearing wear and longer life. It's used in all Worthington radial compressors because it lowers crankpin bearing pressure. One large bearing carries peak connecting rod loads which occur at successive intervals. It's aerodynamically sound because the design is also used in all modern radial aircraft engines.



What important maintenance feature is he demonstrating? When a compressor is operating, valves open and close as many as thirty-three times a second. Valve maintenance is therefore of major concern to all users. Unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves and valve guard seats. This is just one of the many Worthington features which save you time and money.

PC. 6.4

To increase your C. Q., write today for the complete story on Worthington's line of standard compressors. Ask for bulletins H-630-B1 and H-605-B3C. Address Section PC64, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Toronto, Ont.

WORTHINGTON

SPECIFY THESE WORTHINGTON STANDARD PRODUCTS ON YOUR EQUIPMENT

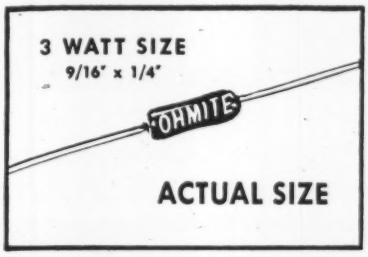
Air Compressors • Pumps • Multi-V-Drives • Allspeed Drives

in the cylinder port or at any convenient location in the airline. Inlet connection is female, outlet, male. Valve body is solid stainless steel; sleeve is brass, with oil-resistant O-ring seals. **Modernair Corp.**, 400 Preda St., San Leandro, Calif.

—Circle ITEM 486

Miniature Resistors

are 3-w, axial-lead units



These small power-type resistors (axial lead) are wire-wound with steatite cores and a vitreous-enamel coating. Because all parts are thermally balanced to expand and contract as a unit, the resistors stand up under high operating temperatures without loosening of terminals or cracking. Small size adapts them to use in printed circuits, terminal-board and point-to-point wiring applications. Resistance values run from 1 to 10,000 ohms in ratings from 3 to 10 w. **Ohmite Mfg. Co.**, 3677 Howard St., Skokie, Ill.

—Circle ITEM 487

O-Ring Lubricant

is applicable at temperatures from −20 to 400 F

O-Lube grease provides lubrication without deteriorating effects for synthetic rubber O-rings and prevents dryness. The material is recommended for low-pressure pneumatic and vacuum systems, such as on exposed cylinder rods and valve plungers. It adheres well and has good water resistance. Temperature range is from −20 to 400 F. Grease is applied to the O-ring and the metal surfaces over which it slides. **Parker Appliance Co.**, Rubber Products Div., 17325 Euclid Ave., Cleveland 12, O.

—Circle ITEM 488

Now...

Norgren MICRO-FOG Lubricators

for 32, 200, 300 and 1000 BEARING INCH REQUIREMENTS

For Lubricating

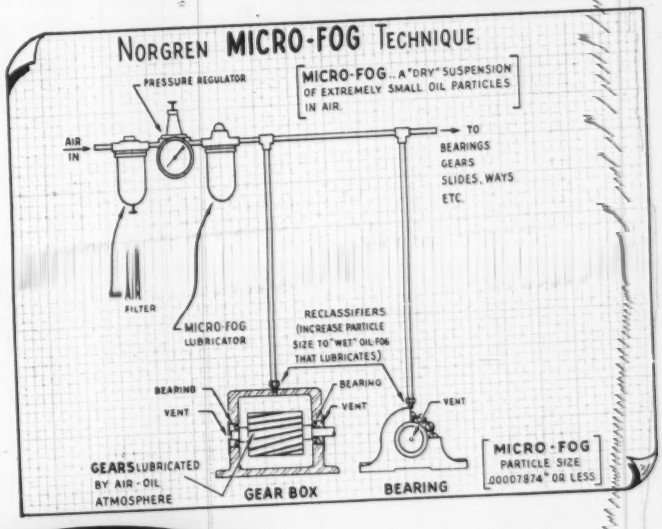
Bearings • Gears • Ways • Chain Drives • Cams • Slides • Other Machine Components

Model S3406-8S
1 quart oil capacity
300 bearing inch capacity
1 inch pipe size

You can now choose a specially designed Norgren MICRO-FOG Lubricator that has the bearing inch capacity that will provide the most effective lubrication for any machine.

Why Norgren MICRO-FOG Provides Better Lubrication

1. Norgren MICRO-FOG automatically supplies just the right amount of oil for lubricating machine components—no more, no less.
2. The advanced design of Norgren MICRO-FOG Lubricators makes possible complete machine tool lubrication with a minimum of air consumption.
3. Norgren MICRO-FOG remains suspended in the air stream and can travel many times farther than oil fog from conventional lubricators, and can be uniformly distributed to multiple lubrication points.
4. The delivery of Norgren MICRO-FOG to machine parts is precisely controlled. MICRO-FOG is delivered at a uniform rate regardless of the supply of oil in the reservoir.
5. Air-borne Norgren MICRO-FOG maintains a lower operating temperature for high speed parts—reducing wear, improving performance, increasing machine life.
6. The slight air pressure in bearing or gear housings prevents entry of foreign material.
7. 360° visibility of oil flow simplifies adjustment of oil feed rate, and provides visual assurance that the lubricator is operating.



C.A. Norgren CO.

3442 So. Elati, Englewood, Colo.

For complete information about Norgren MICRO-FOG Lubrication, phone your nearby Norgren Representative listed in your telephone directory—or

WRITE FOR NEW NO. 700 CATALOG

PRESSURE REGULATORS • AIR LINE FILTERS • LUBRICATORS • AIR CONTROL VALVES

—ITEM 639—

20 Years OF OUTSTANDING PERFORMANCE

have made Durakool Tilt-Switches and Timer-Relays the Recognized Standard of Industry.

Now celebrating its 20th year, Durakool, Inc., is proud of the many records of achievement set by its mercury tilt-switches and timer relays.
The basic "Sealed under pressurized hydrogen" principle has been proved on thousands of applications. So successful have they been that they are now the accepted standard of industry:

★ Millions of contacts or cycles without faltering
★ Outlasts the normal equipment life
★ Trouble-free under every practical temperature or humidity condition
★ Low cost

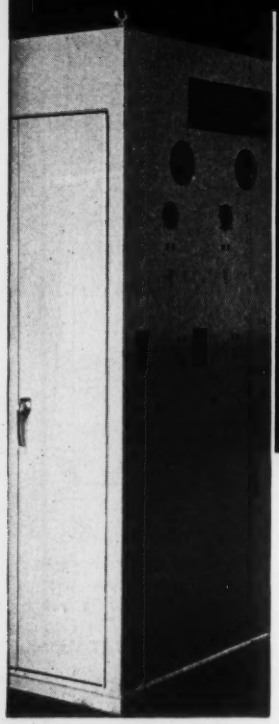
See telephone directory for local distributer, or write.

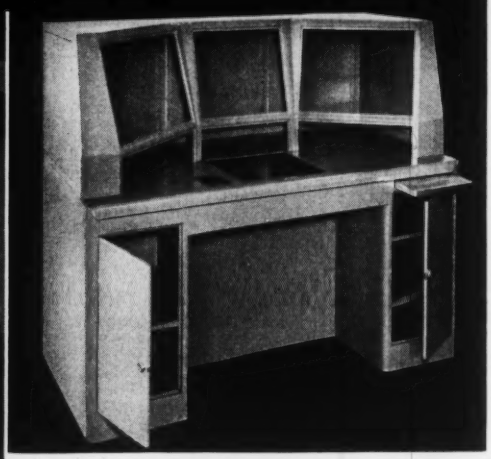
DURAKOOL INC. • ELKHART, IND., U.S.A.
700 WESTON RD., TORONTO 9, CANADA

Durakool

—ITEM 640—

LITTLEFORD beautifully fabricated low cost cabinets and control panels





SMART ENGINEERING AND SKILLED FORMING techniques make the big difference in Littleford fabricated cabinets, cubicles and control panels. In addition, you get prices far below your own fabricating costs, and deliveries to meet *your* production schedules. Hard to believe? Send us your blueprints today for quotations and deliveries. Littleford Bros., Inc., 424 E. Pearl St., Cincinnati 2, Ohio.

ENGINEERING DEPARTMENT

EQUIPMENT

Miniature Accelerometer

weighs 1 oz, has dimensions of ¾-in. cube

Model A-8 variable-reluctance miniature accelerometer, developed primarily for flight-test applications, weighs 1 oz and measures ¾-in. on an edge. Full-scale output is 40 mv per v input; input voltage is 10v, nominal. Range full scale is ±5 *g* to 300 *g*; natural frequency is 200 cps on the low-range instrument, 1500 cps on the high-range unit. Small size and weight permits use where an appreciable load must not be placed on the member that is to be instrumented. It is not damaged by overloads of 500 per cent. **North American Instruments Inc.,** 2420 N. Lake Ave., Altadena, Calif.

—Circle ITEM 489

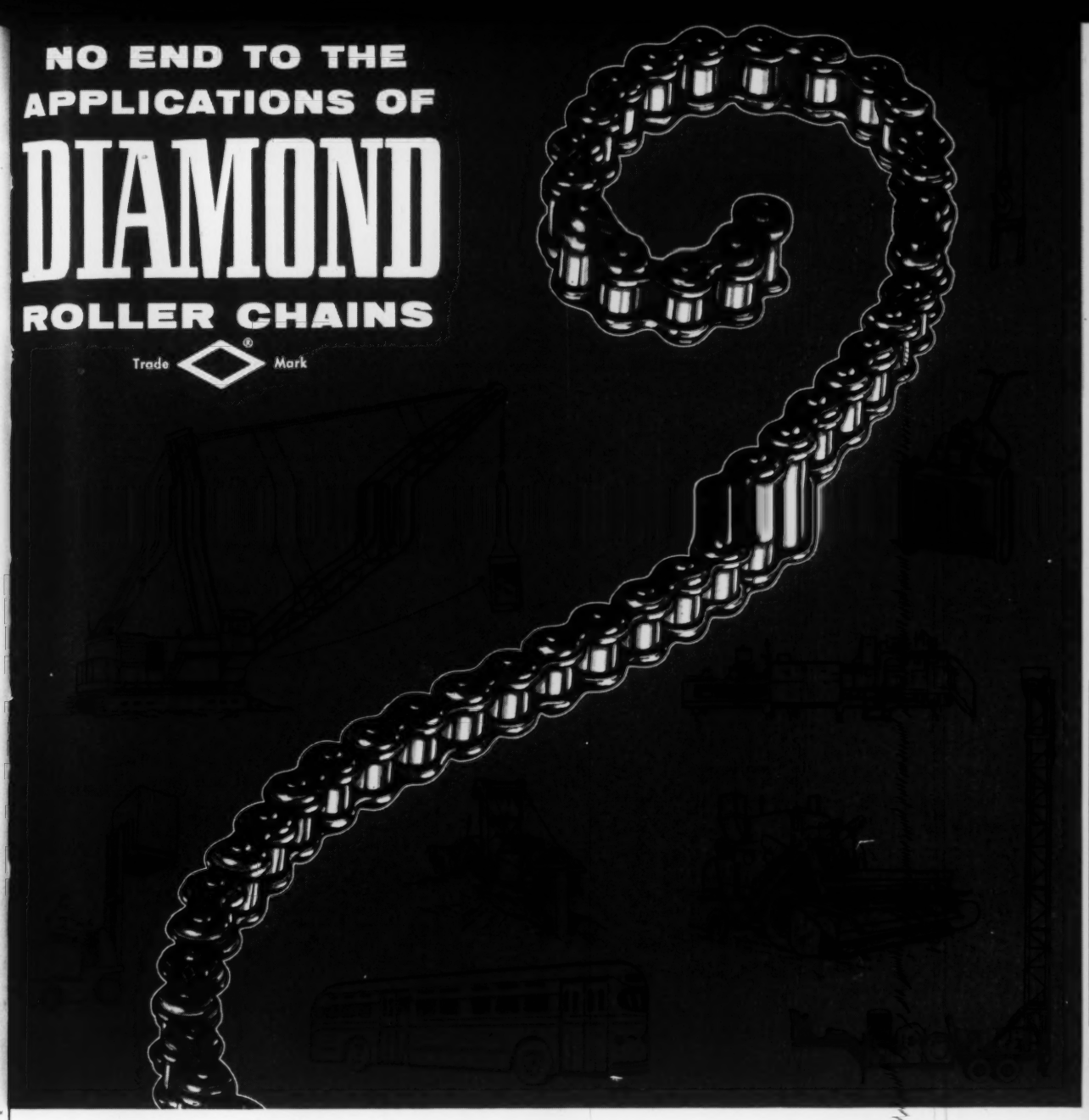
Thermistor Kits

permit evaluation of versatile semiconductors

Available in three kit sizes, these thermistor sets include representative semiconductors in a wide range of resistances, temperature coefficients and styles. Kits enable designers to investigate and evaluate these versatile ceramaic units in experimental circuits. Methods for designing thermistor temperature-correcting networks, performance curves, and other engineering in-

NO END TO THE APPLICATIONS OF DIAMOND ROLLER CHAINS

Trade ® Mark



WHEREVER POWER IS TRANSFERRED

Diamond Roller Chains are in successful application on equipment of every kind—wherever power is being transferred.

Wherever goods are moved, conveyed, lifted—wherever there is construction work, agricultural operation, mining—wherever power is transmitted or shafts driven in factory and mill—there you will find Diamond Dependable Power Transfer.

Wherever put to work, their universally acknowledged characteristics of high uniform quality, reserve strength and long-life low-cost performance provide for product and output improvement.

Over 65 years of experience devoted to this one product is at your disposal. For any application you have in mind, Diamond engineering staff can help you with sound recommendations.

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

Catalog 754 mailed on request. 64 pages of useful information.

DIAMOND ROLLER CHAINS

THE LATEST NEWS ON SIMPLIFYING DESIGN

John Macadam, one of National's staff of applications engineers, displays example of the forming versatility of vulcanized fibre.

Versatile Vulcanized Fibre by National reduces cost of dies and molds and simplifies parts for fast assembly.

Today's big news in product design is simplification through the use of molded plastic parts. But molding may not be your best answer. *Formed fibre* is often a cheaper—and better—solution!

Look to National Vulcanized Fibre as an engineering material with these advantages:

Lower die or mold costs

Excellent forming qualities

Greater durability—toughness plus resilience

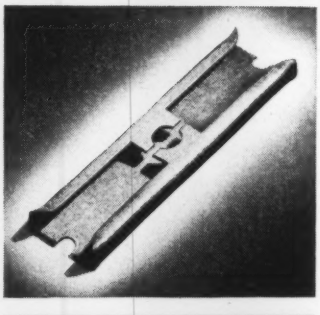
Good heat resistance and dimensional stability

Low material cost

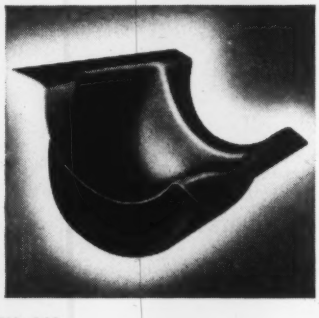
National Vulcanized Fibre and its unique combination of mechanical and electrical properties suit this lightweight, low-cost material to hundreds of difficult applications. And National's generations of experience can always be tapped for answers to your problems.

The typical examples on this page show what can result when our skilled technicians apply versatile vulcanized fibre to your particular job. Consult your nearest National representative about your current materials problem—or write Wilmington, Delaware, Dept. G-5.

Drawn and formed in one operation, the hip guard shown here possesses the resilience, toughness and shape retention that make vulcanized fibre the most used material for protective athletic equipment. Channel draw strengthens structure yet retains necessary spring. The piece is dipped, then baked with synthetic enamel for moisture protection and good appearance.



Punched, formed, scived and flared, this insulator component shows the successful solution of a difficult problem—boxing a channel on all four sides. In fabricating, the blank of vulcanized fibre was first cut to contour, after which the ends were scived, then formed into a box section and flared. This combination of operations makes the piece unusual.



Formed and deep drawn to a depth of 7 inches, this welder's helmet demonstrates the extreme workability of vulcanized fibre. Fabrication was by a single draw with an open bottom die—i.e., fibre was pulled in four different directions. Drawing depth and radii curve are about the maximum limit.

NATIONAL VULCANIZED FIBRE CO.

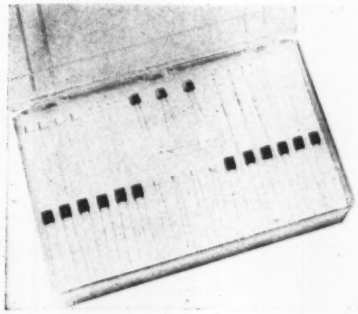
WILMINGTON 99, DELAWARE

In Canada: **National Fibre Company of Canada, Ltd.** • Toronto 3, Ont.

VULCANIZED FIBRE • PHENOLITE LAMINATED PLASTIC • PEERLESS INSULATION
KENNETT MATERIALS HANDLING RECEPTACLES • VUL-COT WASTEBASKETS
LESTERSHIRE TEXTILE BOBBINS • VULCOT PRODUCTS FOR THE HOME

—ITEM 643—

For More Information Circle Item Number on Yellow Card—page 19



formation are furnished with the kits. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J.

—Circle ITEM 490

Digital Ohmmeter

displays 0.1 to 10 megohm resistances to five digits

Model D050 digital ohmmeter, with five-digit display, has a range of 0.1 ohm to 10 megohms, and is accurate to 0.01 per cent ± 1 digit, depending on the range. Measurements are made automatically and are presented on a digital inline read-out with 1 in. numerals. Average read-out time is 1 sec; range switching is automatic. Measuring 7 x 19 x 16 in., the instrument is designed for rack mounting. Required operating power is 115-v, 60-cycle, 50-w, ac. **Electro Instruments Inc.**, 3749 Rosecrans St., San Diego 10, Calif.

—Circle ITEM 491

Reproduction Machine

is completely self-contained

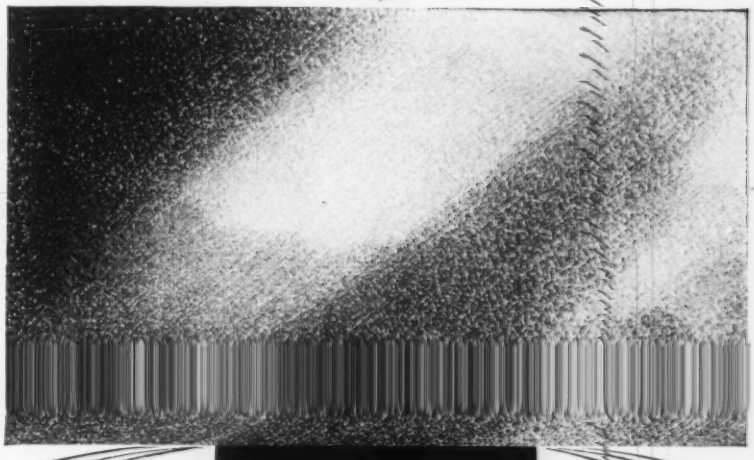
Designed to provide "inside" reproduction facilities for small engineering and architectural firms, model 300 table-top diazo reproduction machine incorporates the following features: 30 in. printing width, maximum mechanical speed of 8 ft 10 in. per min, variable-speed drive, 1200 w quartz lamp,

AMSCO®

MANGANESE STEEL

the toughest steel known for...

IMPACT



ABRASION

Amsco Manganese Steel actually *absorbs impact energy*. Impact work-hardens the steel's surface to as high as 550 BHN, while retaining high *ductility* beneath the hardened surface. This is a tough steel with the superior ability to *resist abrasion*. The more it is used, the harder and more polished the surface becomes. These are the characteristics of manganese steel that minimize wear and reduce the need for frequent lubrication.

The slow *crack propagation* rate of the steel allows for an *early discovery* of impending failure, even at arctic temperatures.

For a *complete technical discussion* of this high-strength "toughest steel known," write for *your* free copy of booklet, *Austenitic Manganese Steel*, Amsco Division, Chicago Heights, Illinois.

AMERICAN Brake Shoe COMPANY

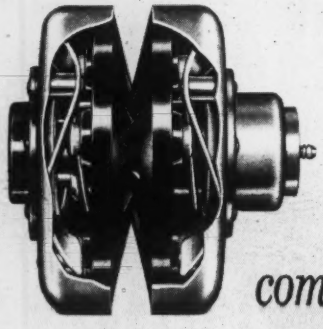
AMSCO

American Manganese Steel Division

Chicago Heights, Ill.

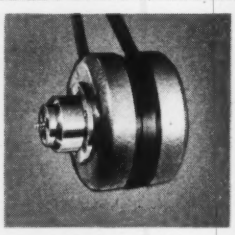
—ITEM 644—

DESIGN-WISE...



this simple pulley solves complicated problems

Compactness of *HI-LO* automatic variable speed pulleys simplifies basic machine design in a vast range of applications. The exclusive design of cam followers on cams provides simple, positive pitch diameter setting control. Springs in HI-LO pulleys are not driving members as in most spring-loaded pulleys, but serve primarily to keep the pulley faces in contact with the belt. Belt wear is reduced to a minimum because the belt is never under any more tension than is required by the load. Free technical manuals with diagrams, descriptions of applications and other power transmission data are available from:



Equipment Engineering Company

2855 Columbus Ave., Minneapolis, Minnesota

—ITEM 645—

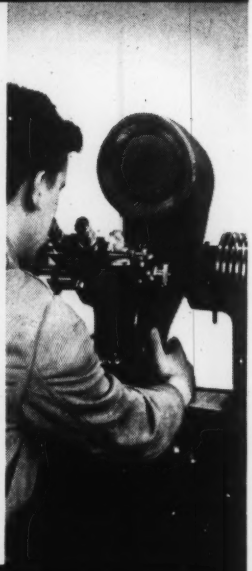
Another of the Reasons Behind Brad Foote Quality—

METALLOGRAPHY

• The heat treatment a gear receives is probably the most important single factor in determining its long range wear characteristics. Here at BRAD FOOTE we pride ourselves on having equipment designed to provide the widest possible variety of heat treatments.

• But in addition to standard heat treating and testing equipment we have a few extra safeguards. One of these, rather unusual in our business, is a complete Metallographic laboratory. Specialized equipment allows us to examine or photograph the grain structure of all of our metals, in order to determine the most effective methods of heat treatment and to serve as a check on the quality of finished work.

• Metallographic examination is just one of the many reasons behind BRAD FOOTE quality. Prove to yourself the savings this extra quality can mean. Let us quote on the gear requirements for your next program, without obligation.



BRAD FOOTE MAKES ALL TYPES OF GEARS—
IN A COMPLETE RANGE OF STYLES AND SIZES

BRAD FOOTE GEAR WORKS, INC.

1309 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • OLympic 2-7700 • TWX CIC-2856-U

subsidiaries

AMERICAN GEAR & MFG. CO.
Lemont, Illinois • Phone Lemont 920

PITTSBURGH GEAR COMPANY
Pittsburgh 25, Penn. • Phone SPalding 1-4600

Engineering Equipment

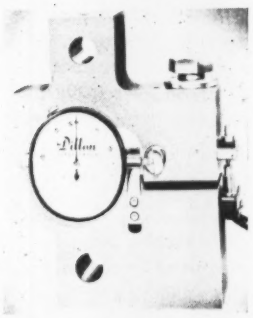
and 12 x 30 in. rear delivery tray. The machine is completely self-contained and operates on 115 v, 60 cycle ac. No darkroom facilities or auxiliary equipment are required. Exposure and development are automatically synchronized. **Charles Bruning Co. Inc.,** 4700 Montrose Ave., Chicago 41, Ill.

—Circle ITEM 492

Force Gage

is accurate to 1 per cent in 50,000 lb range

Available in models for either compressive or tensile testing, this compact force gage has a warranted accuracy of 1 per cent of the indicated reading and a range of 0 to 50,000 lb. Tensile instru-



ment (illustrated) has eyes for insertion of clevises and a safety-stop bolt to prevent undue expansion of the open end of the gage. Accidental overloads beyond the gage's normal 25 per cent safety factor merely cause the upper portion of the gage to come to a positive stop against the bolt head. Compression model has recessed cup for seating a free-riding, hardened-steel ball to ensure vertical thrust. **W. C. Dillon & Co. Inc.,** P. O. Box 3008, 14620 Keswick St., Van Nuys, Calif.

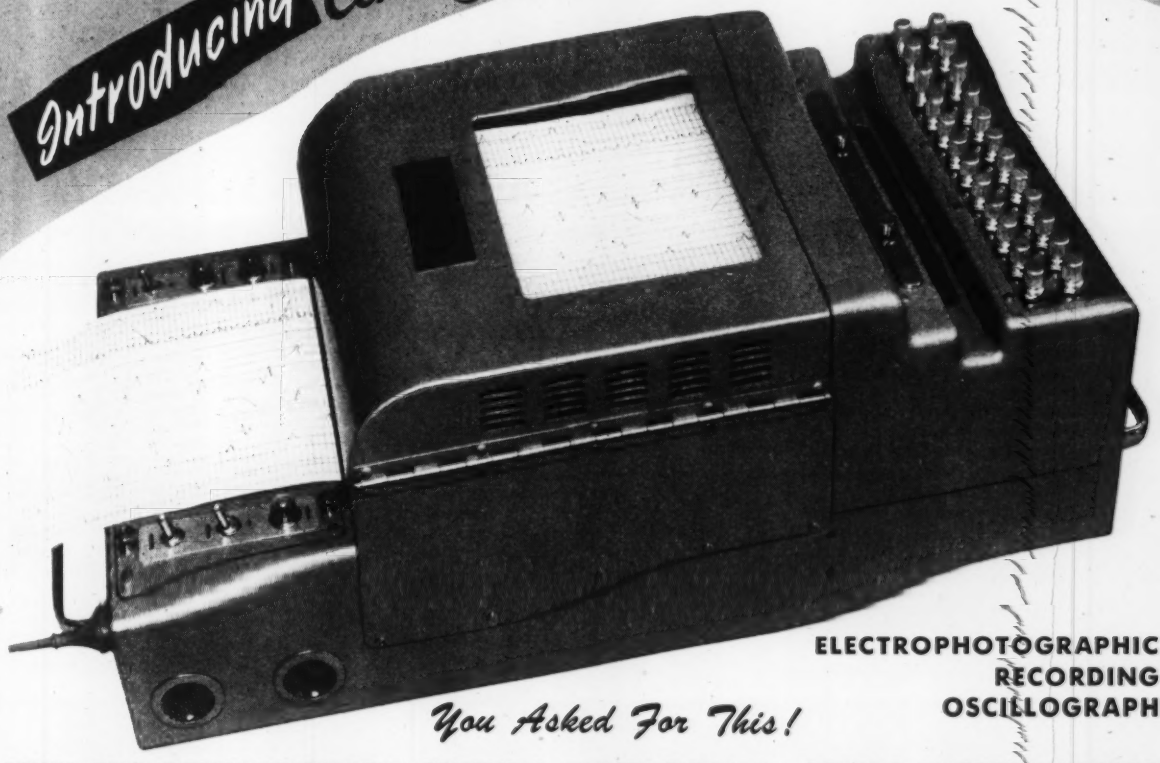
—Circle ITEM 493

—ITEM 646—

NOW! FOR THE FIRST TIME

DIRECT WRITING CONVENIENCE WITH PHOTOGRAPHIC ADVANTAGES!

Introducing Century ELECTROGRAPH MODEL 420



ELECTROPHOTOGRAPHIC RECORDING OSCILLOGRAPH

You Asked For This!

ONLY THE REVOLUTIONARY CENTURY ELECTROGRAPH OFFERS THESE FEATURES

- ***Permanent instantaneous oscillograms***
- ***Eliminates need for messy liquid chemicals***
- ***No darkroom required***
- ***Automatic continuous dry processing***
- ***View oscillogram while recording***
- ***Utilizes sensitive light-beam galvanometers***
- ***Up to 24 traces on eight inch paper***
- ***Traces can overlap***
- ***Precision timing lines***
- ***Low power consumption***

Century's engineers are the first to accomplish the long dreamed-for wedding of photographic recording and completely automatic dry processing to eliminate the need for costly darkroom facilities and liquid developing, rinsing and fixing.

The greatest advancement in the technique of multi-channel oscillograph recording in over 20 years, the CENTURY ELECTROGRAPH is essentially a direct-writing recording oscillograph utilizing the RADICALLY new technique of Electrophotography combined with light-beam galvanometers.

NOW investigate CENTURY ELECTROGRAPH—the most modern approach to simplified oscillographic recording — when planning your instrumentation program whether for research, engineering, test, quality control, process control, or any other analog recording requirement.

COSTS NO MORE THAN OLD-FASHIONED METHODS

Century

Century Electronics & Instruments, Inc.

1333 NO. UTICA, TULSA, OKAHOMA

For further information, call on our nearest representative:

EXPORT OFFICE: 149 BROADWAY, NEW YORK CITY — TEL.: BARCLAY 7-0562

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PHILADELPHIA 40, PA.	LONG ISLAND CITY 1, N. Y.	DAYTON 2, OHIO	DALLAS, TEXAS	TUCSON, ARIZONA	PASADENA 1, CAL.	REDWOOD CITY
TEL.: MICHIGAN 4-1822	TEL.: STILLWELL 4-7120	TEL.: FULTON 9292	TEL.: EMERSON 6716	TEL.: 7-1501	TEL.: RYAN 1-9663	TEL.: EMERSON 6-8214

The Computers Say Carbon

Much of today's material selection is performed by the digital computer. Tabulations of desired properties for a specific application are fed to these machines, and the material selected is most often – carbon. The many versatile physical properties of carbon make it excellent for a diversity of applications...to name a few:

Good Electrical Conductivity – Carbon brushes and contacts, vacuum tube anodes, grid rectifier anodes, and welding products.

Resistance to Corrosion – Bearings for use in acids; plating electrodes; pipe for handling chemicals; linings for acid tanks.

Self-Lubricating – Carbon piston rings; dash pot plungers; nozzles; seals; orifices and inserts in metal bearing surfaces and brake shoes.

No Deformation at High Temperatures Sintering boats, brazing boats and fixtures; molds for powder metallurgy; dies for continuous casting; forms for metal to glass sealing.

Resistance to Severe Thermal Shock – Liners for rocket nozzles, electric furnaces; hearth and wall sections of blast furnaces.

Easily Machined and Fabricated–Carbon structural shapes–beams, blocks, plates and rods.

Let the computer result be your guide and consider carbon for your specific application. Speer Carbon Company can provide practically any product for your need, made to exacting specifications for shape, size, and composition. For information return coupon.

SPEER Carbon Co.

St. Marys, Pa.

Please send information on carbon for use in_____

Name_____

Title_____

Address_____

City_____ State_____

—ITEM 648—

THE ENGINEER'S Library

Recent Books

Thermal Power from Nuclear Reactors. *By A. Stanley Thompson and Oliver E. Rodgers; 229 pages, 5¾ by 9, clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.25 postpaid.*

This book contains an engineering discussion of the application of nuclear reactors to the production of thermal power. Chapters cover the characteristics of physical particles, reactor equations and critical mass, reactor kinetics, shielding of reactors, reactor materials, thermal stress, power extraction from reactors and thermal power cycles.

•

Mass-Transfer Operations. *By Robert E. Treybal, Professor of Chemical Engineering, New York University; 666 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 postpaid.*

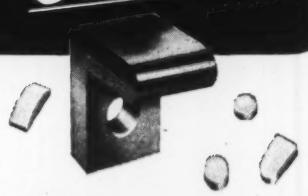
An introduction to the general subject of diffusion and the latest developments in the industrial applications of mass-transfer operations are included in this text. It covers the principles of equipment design, equipment operation, and fields of application.

New Standards

Ring-Joint Gaskets and Grooves for Steel Pipe Flanges, ASA B16.20-1955. *11 pages, 8½ by 11 in., paperbound; published by and available from American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y., $1.00 per copy.*

This edition of B16.20 supersedes the revision dated 1955. The 1956 version includes ring gaskets used with 900-lb ring-joint pipeline flanges in sizes 26 through 36

TRY Gibson FOR SIZE FROM Large TO SMALL Electrical Contacts



• **EXPERIENCE**

Gibson's engineering ability in developing the right electrical contact for the right product is unexcelled . . . whether your product requires large or small contacts, or contacts of odd size or metal combinations.

• **SERVICE**

Gibson pledges to deliver electrical contacts of top quality, on time at a competitive price.

• **COMPLETE LINE**

Gibson offers you a wide selection of electrical contact materials (including Gibsiloy powdered metals), forms (including rivets, steelbacks, stampings, molded parts), and assemblies (either riveted, welded or brazed).

• **FLEXIBILITY**

Gibson's round-the-clock production enables us to meet requirements of every rush job. Consult us when developing new products or improving old ones.

Write for GIBSON Catalog C-520 Contact Gibson First

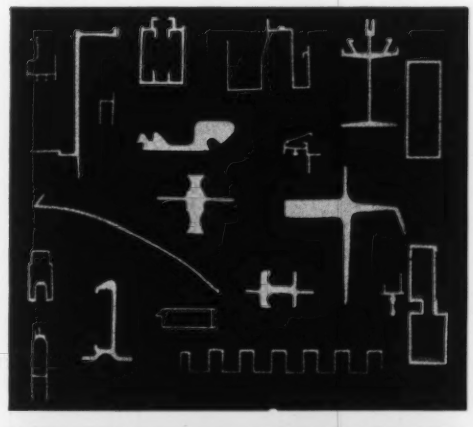
Gibsiloy ELECTRICAL CONTACTS

Manufactured by GIBSON ELECTRIC COMPANY

8355 Frankstown Avenue, Pittsburgh 21, Pa.

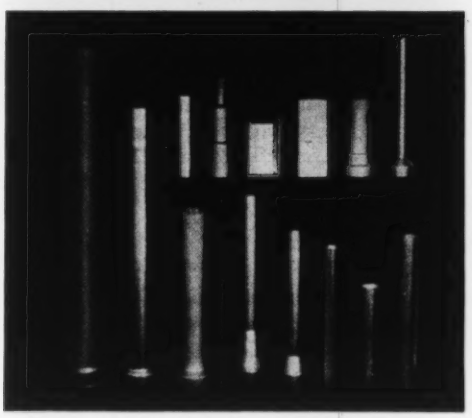
—ITEM 649—

You can make it faster and better with **Harvey Aluminum**



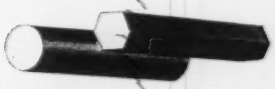
EXTRUSIONS . . . For decorative as well as basic parts, custom-designed aluminum extrusions replace riveted and welded assemblies . . . simultaneously adds strength, simplifies fabrication.

PRESS FORGINGS . . . Where parts must combine maximum strength with savings in weight, cost and manpower, Harvey aluminum forgings often completely solve the problems encountered by the designer.

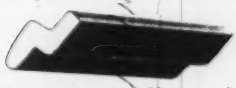


IMPACT EXTRUSIONS . . . Thin-walled, tubular structures can be produced by this method and held to very close tolerances. Machining is practically eliminated; scrap is greatly reduced.

STRUCTURALS . . . High strength, light weight, workability, corrosion resistance. Aluminum extrusions combine all four . . . are ideal as basic load-bearing members.

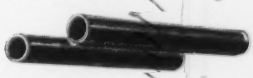


MACHINING STOCK . . . Harvey deep-drawn hex and round stock set a new mark in uniform grain structure—consistent from surface to core. This means fast, chatter-free cutting, long tool life, few rejects and true threads.



FORGING STOCK . . . If you make your own forgings in quantity, Harvey extruded forging stock can save many intermediate steps. Custom-designed extrusions whose cross sections approximate the forged blanks may be cut to length.

EXTRUDED PIPE AND TUBE . . . Seamless . . . uniform in structure, size and shape . . . clean and smooth inside and out . . . easily formed. Usable in applications ranging from portable irrigation systems to aircraft heat exchangers.



DRAWN TUBE . . . Combines strength and high finish . . . ideal for TV antennas, furniture, and similar products. Cold drawn for structural uniformity . . . and the temper is specially controlled for good workability.

SCREW MACHINE PRODUCTS . . . The West's largest installation of multiple-spindle screw machines can reduce your manufacturing costs. Harvey carries your job through from engineering to quality control.

Harvey is a leading independent producer of aluminum extrusions in all alloys and all sizes, special extrusions, press forgings, hollow sections, structurals, rod and bar, forging stock, pipe, tube, impact extrusions, aluminum screw machine products and related products. Also similar products in alloy steel and titanium on application.

MAKING THE MOST OF ALUMINUM . . . FOR EVERYONE

HARVEY Aluminum

HARVEY ALUMINUM SALES, INC.
TORRANCE, CALIFORNIA
BRANCH OFFICES IN PRINCIPAL CITIES

—ITEM 650—
For More Information Circle Item Number on Yellow Card—page 19

KARAK

Non-metallic material or parts for manufacturing your product. "KARAK" is manufactured in various combinations of graphite and carbon. To suit your requirements any combination of these materials can be impregnated. Bearings - rings - molds and cores - seals for liquids - air and grease pumps - Diesel engines - air compressors, etc., represent only a partial list of applications. Day by day many needs are developing in industry where this type of material is found to be superior to materials now being used.

DESIGN WITH "KARAK" IN MIND

We welcome your inquiries!

Basic Manufacturers

THE OHIO CARBON COMPANY

12500 BEREA RD., CLEVELAND 11, OHIO

—ITEM 651—

The Engineer's Library

in. proposed by the Manufacturers Standardization Society of the Valve and Fittings Industry.

Association Publications

Proceedings of the Second U. S. National Congress of Applied Mechanics. 825 *pages, 9 by 11½ inches, clothbound; published by and available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., $9.00 per copy.*

The ninety-nine papers in this book were presented at the meeting held in June 1954 under the sponsorship of the U. S. National Committee on Theoretical and Applied Mechanics. The articles are grouped under the headings (1) general methods, dynamics, vibration and wave motion, (2) elasticity, shells, plates, elastic instability and structures, (3) plasticity, viscoelastic flow, failure and behavior of materials, and (4) fluid flow, aerodynamics, heat transfer.

♦

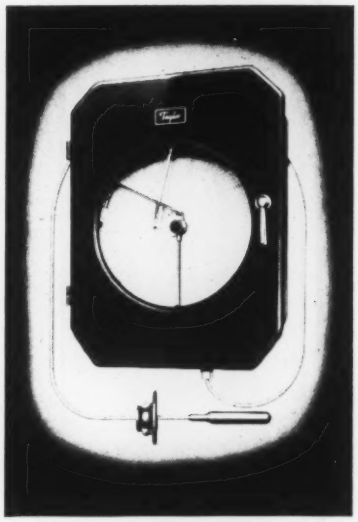
Compilation of Chemical Compositions and Rupture Strengths of Super-Strength Alloys. 8 *pages, 8½ by 11 inches, paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; 75c per copy.*

Designated ASTM Special Technical Publication No. 170, this compilation lists the names, nominal chemical compositions, characteristic rupture strengths for rupture in 100 and 1000 hr, and patentees for approximately 100 domestic alloys and 41 foreign alloys. The compilation does not include the conventional ferritic, martensitic, or austenitic stainless steels.

Manufacturers' Publications

Physical Metallurgy and Heat Treatment of Titanium Alloys. 60 *pages, 6 by 9 in., clothbound; published by and available from Mallory-Sharon Titanium Corp., Niles, Ohio; $1.00 per copy.*

This book describes in detail the heat treatment of titanium alloys. It covers both the metallurgical



Courtesy Taylor Instrument Companies

LOOK NO FURTHER FOR QUALITY...

This Taylor Recording Thermometer, #76JM117, is a one pen mercury actuated recording instrument which includes 5 feet of BISHOP Accuratus* tubing. *(Capillary lengths in excess of 200-feet are not uncommon when the use of Accuratus* tubing is indicated)*

And why BISHOP capillary tubing? Because Taylor uses only the highest *quality* components in its instruments.

The next time you need small diameter stainless steel tubing, look no further for *quality* tubing. BISHOP has it.

Mechanical—Capillary—Hypodermic
Seamless or Welded and Drawn
(.008" to 1" O.D.)

Also, investigate Bishop fabricated parts to save you time and money.

Catalog and Prompt Quotations on Request

J. BISHOP & CO. PLATINUM WORKS

Stainless Steel Products Division
Malvern, Pennsylvania

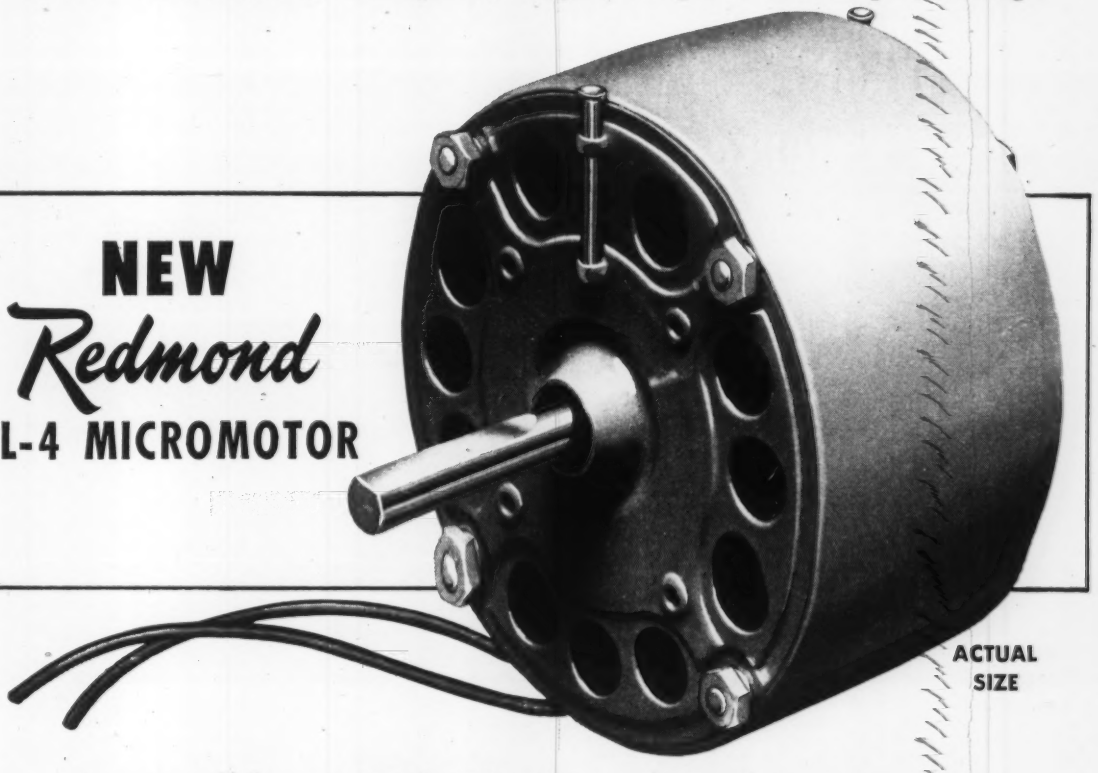
*Trademark

—ITEM 652—

MORE HORSEPOWER . . .

in an Economical, Compact, Lightweight, Quality Package

NEW
Redmond
AL-4 MICROMOTOR



ACTUAL SIZE

Designed for a Wide Variety of Applications . . .
or can be Tailor-Made for Specific Requirements

Here is a motor designed and styled to meet the modern demands for motors that are smaller and lighter, and yet have increased output. It is ideal for heating, ventilating, air conditioning or refrigeration equipment, for appliance applications, and for business and vending machines, pumps, tape recorders, and dozens of other applications.

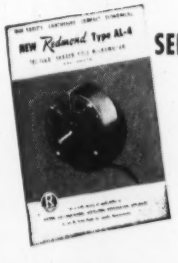
The basic AL-4 is a 4-pole motor, 1550 r.p.m., 115 volts, 60 cycles, available in odd voltages and frequencies. The normal horsepower range is 1/250th to 1/15th. It incorporates two famous Redmond design features that have never before been available in a small diameter motor:

1. The patented Redmond Tri-Flux® design that greatly increases starting and running torque and improves efficiency over conventional small diameter motors;
2. The Uni-Cast® construction that gives a rigid, lightweight motor that can be manufactured to extremely close tolerances.

Because with Uni-Cast construction the stator core frame is precision die cast in one piece, the registers are machined concentric to the bore to extremely close tolerances. The exact bearing alignment and uniformity of air gap achieved with this precision manufacturing result in a motor that is whisper-quiet in operation and can be depended on to give years of trouble-free service.

Casting the stator core frame in one piece not only makes the motor most rigid, but it is light in weight, as a very durable and lightweight metal is used.

This modern motor can save money on a host of applications. If you are looking for a motor in volume quantities, send for the literature described below.



SEND FOR COMPLETE PERFORMANCE DATA

For the complete story on the new AL-4 motor—dimensions, performance, operational data, and suggested applications—write for the "AL-4 Bulletin."

ADVERTISED IN The Saturday Evening POST

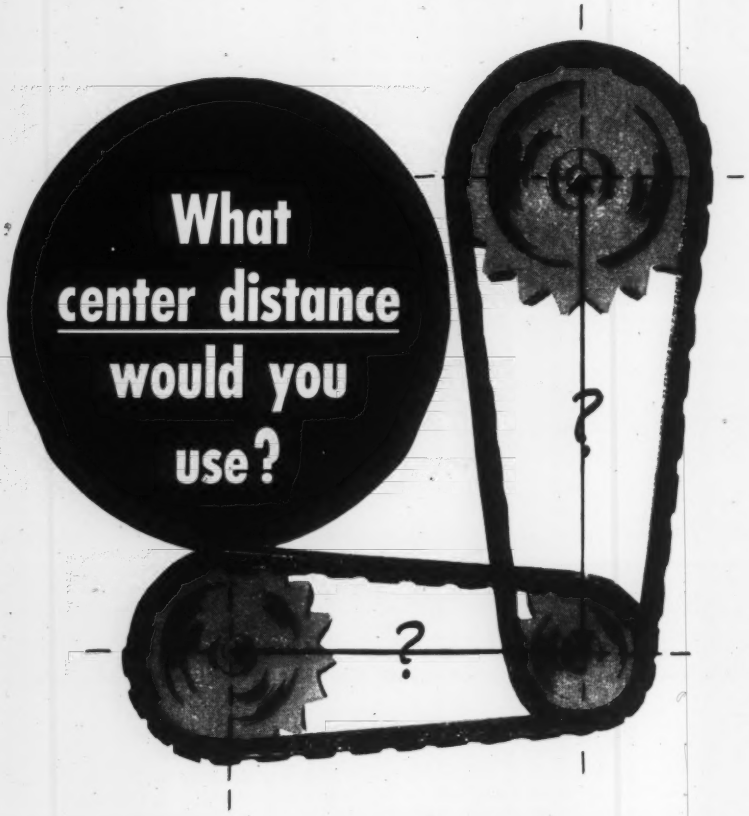
The Standard of Dependability

Redmond
COMPANY, INC.
OWOSSO, MICHIGAN

REDMOND

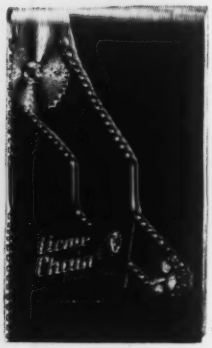
THE **BIG** NAME IN SMALL MOTORS

—ITEM 653—



Maximum power transmission efficiency is obtained when the center distance, in each case, is correct.

Center distances must be more than one half the diameter of both sprockets (otherwise the teeth would touch). Best results are obtained when a center distance of 30 to 50 times the pitch of the chain is used. Eighty times the pitch is considered maximum. For pulsating drives, the center distance should be shortened to 20 to 30 times the pitch. Chain sag should be equivalent to approximately 2% of the center distance.



ACME ENGINEERS OFFER FREE ADVISORY SERVICE. Whatever the problem, Acme Chain Engineers are always willing to lend a hand. Call direct to Acme for sound advice or field assistance.

FREE TEXT. Designers and engineers may write for a free copy of this 76 page chain text. It's loaded with chain data, specifications, illustrations and facts you should know about chain applications. Write ACME CHAIN CORP., Dept. 6-E Holyoke, Mass.

Write or Call JE 2-9458 for immediate delivery or engineering service.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

—ITEM 654—
For More Information Circle Item Number on Yellow Card—page 19

The Engineer's Library

theories and the practical heat treatments for annealing and hardening. Typical mechanical properties which can be expected of commercial titanium alloys in various heat treated conditions are included.

♦

Casting Aluminum. 130 *pages,* 5¾ *by* 8¾ *in., paperbound; published by Reynolds Metals Co.; available on company letterhead request from the publisher, Desk PR4810,* 2500 *South Third St., Louisville* 1, *Ky.*

This booklet is intended to help the designer select the casting process and aluminum alloys best suited to his products. Data on typical mechanical properties are presented. Brief discussions cover master alloys, hardeners, and the six main casting methods.

♦

Transistors I. 676 *pages,* 6 *by* 9 *in., clothbound; published by RCA Laboratories, Princeton, N. J.; available from* The RCA Review, *David Sarnoff Research Center, Princeton, N. J.;* $4.50 *per copy in the U. S.,* $4.70 *elsewhere.*

This book is a selection of papers describing research and development work of RCA as it applies to the theory, fabrication and application of transistors. The papers are grouped in six sections: general, materials and techniques, devices, fluctuation noise, test and measurement equipment, and applications.

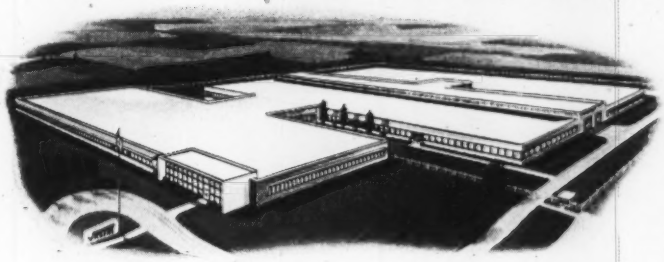
Government Publications

A Survey of Domestic Electronic Digital Computing Systems, PB111-996. *By Martin H. Weik;* 272 *pages,* 8½ *by* 11 *in., paperbound; published by Ballistic Research Laboratories, Aberdeen Proving Ground, Md.; available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.,* $4.75 *per copy.*

This report is a result of a survey of 84 systems made in the U.S. Included for each system are general and detail descriptions, illustrations, designs, applications and operating characteristics.

VICKERS

NEW RESEARCH and ENGINEERING CENTER



Offers Diverse Engineering Opportunities in Commercial and Military Hydraulics

Phenomenal and continuing expansion in the use of oil hydraulics by an ever-increasing number of industries brought the need for this new Vickers 150,000 square foot building (in suburban Detroit) devoted primarily to research and engineering.

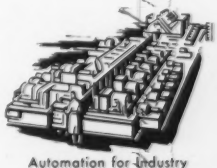
Here is an abundance of opportunity for engineers at all levels to grow in professional stature and income. The range of opportunity is as wide as industry itself, because Vickers is a major supplier of hydraulic components in all the fields illustrated below. The continuity and stability of opportunity are assured by the increasing growth rate of hydraulic applications . . . both industrial and military.

Vickers is going places . . . go places with Vickers.

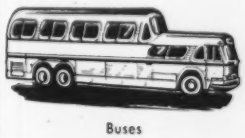
Farm and Industrial Tractors

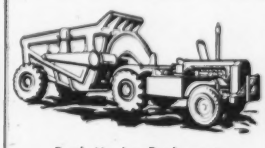
Commercial Aircraft

Military Aircraft

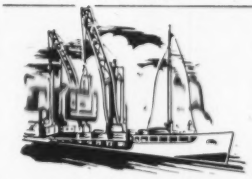

Automation for Industry

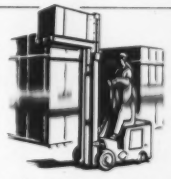
Automobiles

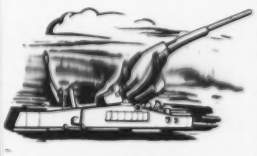

Buses

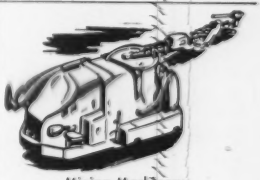

Earth Moving Equipment

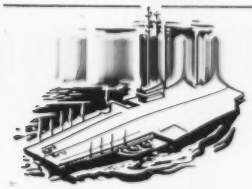
Agricultural Machinery

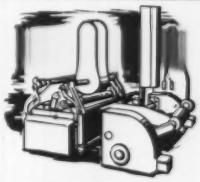

Commercial Vessels

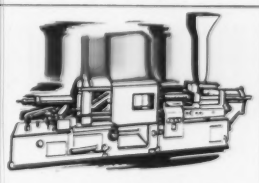

Materials Handling Equipment

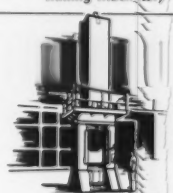

Atomic Weapons

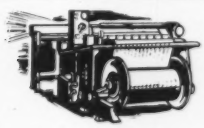

Mining Machinery


Naval Vessels


Paper Machinery


Plastic Molding Machines


Metal Presses


Textile Machinery

Trucks (all sizes)

Typical applications of Vickers Hydraulics . . . components and complete systems with electronic or mechanical control . . . are shown above. Vickers has been supplying these (and many more) for a number of years . . . is not a newcomer in the field of hydraulics. Obviously, this extreme versatility offers challenging opportunities for engineers with a wide variety of talents and interests. For further information, get in touch with Mr. R. E. Barlow. Phone him at Liberty 9-1122 or write him at:

VICKERS INCORPORATED

Division of Sperry Rand Corporation

Administrative and Engineering Center • Detroit 32, Mich.

Vickers has excellent opportunities also in these Divisions:

El Segundo Division
El Segundo, Calif.
Write or call Mr. J. R. Rea,
ORegon 8-2503

Waterbury Division
Waterbury, Conn.
Write or call Mr. George Gillespie,
PLaza 6-3681

7484A

Engineers and Builders of Oil Hydraulic Equipment Since 1921

—ITEM 655—

For More Information Circle Item Number on Yellow Card—page 19

NEED RELAYS?

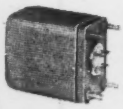
SPECIFY

AEMCO

and get more for your relay dollar!

Pick the size you want . . . choose the features you need . . .

you'll find that an AEMCO relay will *meet* or exceed your specifications. Compact in design, dependable in performance, AEMCO relays are manufactured with extreme care —the choice of more than 100 top names in American industry—and here are the reasons why:



Lower cost—due to modern production techniques and fresh, new engineering ideas. All AEMCO products are designed with shortcuts and specific production economies in mind.

Top quality—based on more than 30 years experience. We'll work closely with your design engineers, and we'll do it without red tape or confusion.

Many standards—to choose from. AEMCO relays are available in a wide variety of spring and coil combinations, operating potentials, and contact ratings. Types include: open, can, plug-in base, hermetically sealed, midgets, dual-purpose, delayed make or break, circuit control, current, and potential relays.

Speedy prototype delivery—and quick tool up for production. Yes, at AEMCO we're selling service as well as design and manufacturing ability.

AEMCO

For more information on the standard AEMCO relay line, write for your free descriptive bulletin today!

AUTOMATIC ELECTRIC MFG. CO.

81 STATE ST. • MANKATO, MINNESOTA

—ITEM 656—

New Machines

Materials Handling

Magnetic Vibratory Feeders: Hi-Vi electro-permanent magnetic vibratory feeders handle a variety of bulk materials from large pieces to fine powders. They operate directly on 115 or 230-v ac without a rectifier. Remote control unit, equipped with a rheostat to vary the voltage across the unit, provides flexible control of the feed rate. Enclosed drive element combines an electromagnet with an Alnico V permanent magnetic armature. This magnetic system causes the material in the tray to move forward. Three standard models have the capacity to move 2, 4 or 10 tons of dry sand per hour in normal operation. Trays are available in a variety of shapes, and are made of 16-gage steel or 16-gage 304 stainless steel. Many units have weather and dust-resistant housings. *Eriez Mfg. Co., Erie, Pa.*

Platen Conveyors: Conveymatic heavy-duty conveyors are available in lengths up to 100 ft and can be lengthened in 10-ft multiples. Standard models have 36, 38 or 40-in. working heights; 12-in. steel platens, each providing a working area 12½ in. wide; 4000-lb chain pull; continuous variable speed range from 100 to 300 fph; overload cut-out clutch and push-button control panel which meets JIC standards. Either right or left hand offset drive is available. *Visitrol Engineering Co., Detroit.*

Metalworking

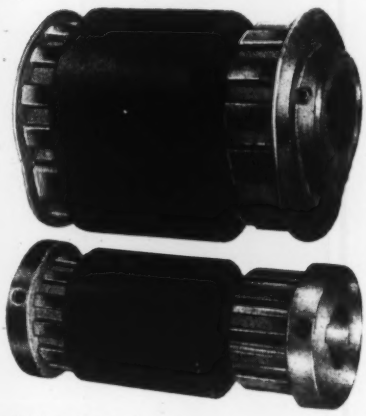
Face Grinders: Improved Series UK traveling wheel face grinders perform precision grinding of long or bulky work pieces at 90 deg to the wheel face. The heavy-duty machines provide high horsepower for heavy stock removal and have a heavy carriage. The work piece is clamped in a stationary position and the grinding wheel passes over the surface to be ground. Stationary table permits

NEW . . . NEW!

Gear-Grip

Flexible Coupling

The most revolutionary design advancement for integral H.P. in a century!

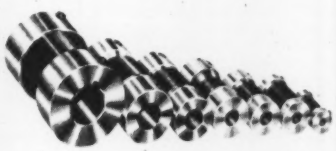


Positive power transmission of rated load. Gear teeth on end castings match special rubber tube section.

- **Load ranges—2½ H.P. to 25 H.P.**
- **Shaft sizes—¾" to 1⅞".**
- **Specified lengths to design requirements.**
- **Prevents end thrust.**
- **"By Eye" shaft alignment.**
- **No lubrication required.**
- **Shaft Safety features.**

Dyna-Line . . .

The finest flexible coupling in single unit construction — specifically designed for fractional H.P.



5R 4R 3R 2R 1R OR OOR

- **True Flexibility and Torsional Resilience for quiet, load-plus power transmission without extreme deflection or twist.**
- **Lengths varied to design specifications in each series.**
- **Load ranges—1/15 to 1½ H.P.**
- **Shaft sizes — 3/16" to ¾".**
- **Lowest O.D. for highest torque capacity.**

Write for Catalogs and Technical Bulletins.

Guardian PRODUCTS CORP.

COUPLING DIVISION

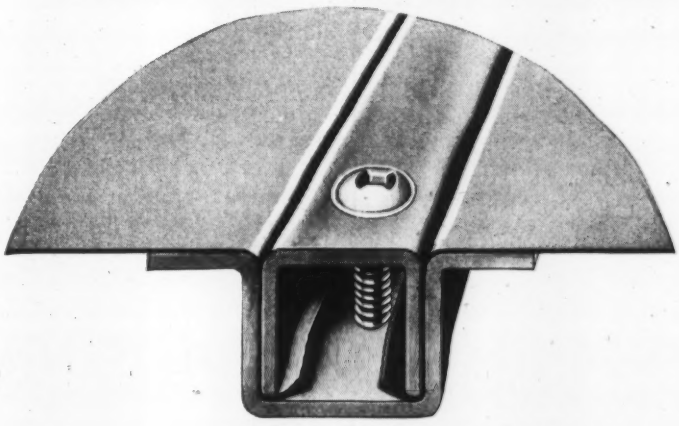
DEPT. P-56, 1215 E. SECOND ST.

MICHIGAN CITY, INDIANA

—ITEM 657—

If You Need Metal Enclosures • Save Time and Tooling with

LINDSAY PREFABRICATED ASSEMBLIES



ONLY 4 BASIC PARTS
YET APPLICATIONS FOR LS PANEL ARE UNLIMITED

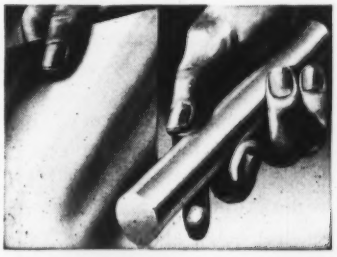
Your production of attractive metal enclosures can be reduced to a simple assembly operation with Lindsay Structure—the patented method of using *pre-tensed* sheet metal panels in light structures of tremendous strength and rigidity.

Lindsay prefabricated assemblies are tailored to your exact needs from die-formed standardized Lindsay Structure components... fabricated in 78,085 panel sizes... available in mild steel, stainless steel, copper, or aluminum... shipped k/d for quick assembly with standard tools—no welding or riveting required. LS shipments can be scheduled to keep pace with your production needs. Fast service on pilot units.

Lindsay Structure has almost unlimited applications—cabinets, housings, refrigerator buildings, processing rooms, dryers, towers, bodies for trucks, trailers, buses, etc.

Put this versatile prefabricated structure to work for you... simplify designing, save on dies and tooling, conserve skilled man power. Write for descriptive folder or send single line drawing for prompt cost estimate.

LS CONSTRUCTION UTILIZES GREAT STRENGTH OF LIGHT SHEET METAL



This 24-gauge, 36-inch wide sheet under uniform tension has greater tensile strength than a 1-inch rod. By a strong, continuous and equalized gripping of the entire sheet, the weaknesses of rivet holes and welds in thin sheet metal are eliminated ... diagonal gussets and struts are made unnecessary.

LINDSAY

Lindsay Structure, Inc.
5019 West Dempster St., Skokie, Illinois

LS STRUCTURE

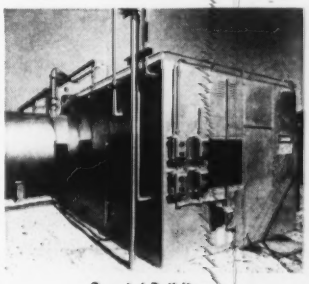
U.S. Patents 2017629, 2263510, 2263511
U.S. and Foreign Patents and Patents Pending

LS SAVES ON—

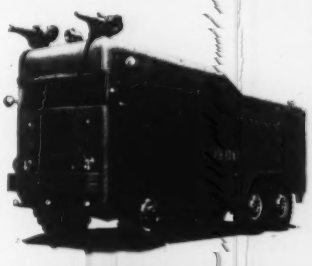
- √ DESIGNING
- √ TOOLING
- √ PROCUREMENT
- √ FABRICATION
- √ INVENTORY
- √ WAREHOUSING
- √ MAN POWER

Mobile Laboratories

Cabinets



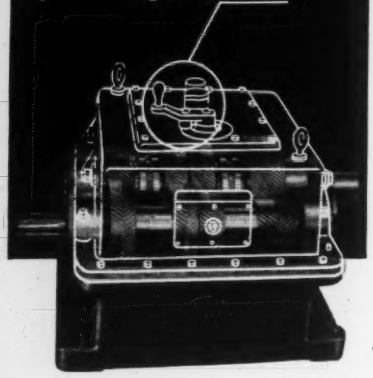
Special Buildings



Crash Trucks

—ITEM 658—
For More Information Circle Item Number on Yellow Card—page 19

GET THE SPEED YOU NEED
by turning the lever



PHILADELPHIA

"Standardized"
Geared
Selective Type

These self-contained, compact all geared type change speed Units are available in 2, 3 and 4 speed changes, providing definite ratio of speed reducing, speed increasing (or a combination of both). They were designed to fill industry's need for a very efficient, precision-built *standardized line* . . . to eliminate the high cost and delayed delivery of specially designed units. They are ideal for use on wire drawing machines, large machine tools, mixing equipment, sludge pumps, extruding machines, dry cleaning equipment, etc. Gears and pinions are Sykes Continuous Tooth Herringbone type, and shafts, bearings, clutches and housings are of the finest quality to assure the user of long, trouble-free service . . . Ratings are according to AGMA Standards, with allowance for 100% overload in starting and for momentary shock loads; these units are also designed to permit the heavy overhung loads resulting from the use of sprockets or pulleys.

Send for Catalog CSU-54, and kindly use your Business Letterhead when writing for same.

phillie gear
PHILADELPHIA GEAR WORKS, INC
ERIE AVE & G STREET PHILADELPHIA 34 PENNA
Offices in all Principal Cities
INDUSTRIAL GEARS & SPEED REDUCERS
LIMITORQUE VALVE CONTROLS
FLUID AGITATORS • FLEXIBLE COUPLINGS
Virginia Gear & Machine Corp. • Lynchburg, Va.

—ITEM 659—

the use of heavy fixtures and clamps. The carriage is driven by a variable volume piston type hydraulic pump in conjunction with a vane type fluid motor. Control of all machine functions is governed by a servomechanism. Rate of speed, starting and stopping, inching and positioning for unloading are controlled by pushbuttons from the operator's seat on the traveling wheel carriage. Speed of the carriage is 10 to 100 fpm. *Mattison Machine Works, Rockford, Ill.*

Welding Machines: Heliwelders, available in 200 and 300 - amp models, are designed for inert-gas and metallic arc welding. Each machine consists of a single-phase transformer, selenium rectifier and stabilizing reactor, permitting the use of ac or dc for welding. Rheostat-controlled high frequency is built in. A switch converts the machine from inert-gas to metallic arc welding. *Air Reduction Co. Inc., Air Reduction Sales Co. Div., New York.*

Processing

Wire Marking Unit: No. 245 marking unit is designed for continuous indentation marking of identifications on bare rectangular wire to $\frac{5}{8}$-in. wide by $\frac{1}{4}$-in. and round wire to $\frac{1}{4}$-in. diam. It is equipped with two self-centering, adjustable guide rolls, a back-up roll and a 4-in. diam marking roll to produce an impression about every 12 in. With characters of 1/32 or 1/16-in. size, controlled depth impressions are from 0.002 to 0.003-in. The unit is free rolling and has a friction drive. It can be equipped with a mortised marking roll to hold single or multiple-character steel inserts. Separate sets of rolls are necessary to mark both flat and round wire. *Jas. H. Matthews & Co., Pittsburgh.*

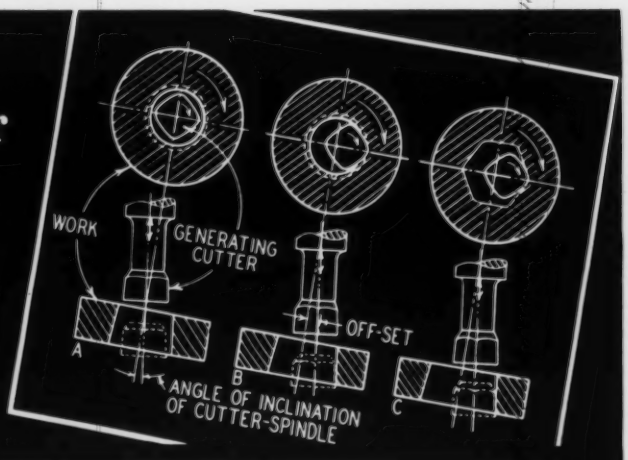
Paint Heater: Portable heater for hot-spraying paint is designed for applications where the painting equipment must be moved to the job site. The complete heater is mounted on a two-wheeled cart. With the unit a dense coat of paint can be built up, since a large amount of solid is deposited in any one area. Lower atomizing pressures can be used, to lessen air consumption. The hot spray process makes possible uniform coating and heavy film build, and is unaffected by seasonal temperatures. The heater is available with either 3 or 6 kw heaters, the 3 kw model operating on 115 v and the 6 kw on 230 v. More than one spray gun can be used with the 6kw model. Fluid hose to the gun is equipped with a heat jacket through which hot water circulates to keep paint temperature constant. Temperature of the water in the unit is controlled by a manually set thermostat. *DeVilbiss Co., Toledo, O.*

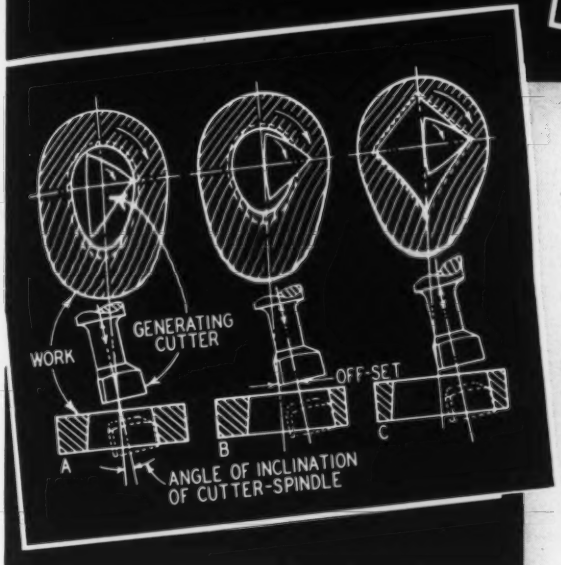
Testing and Inspection

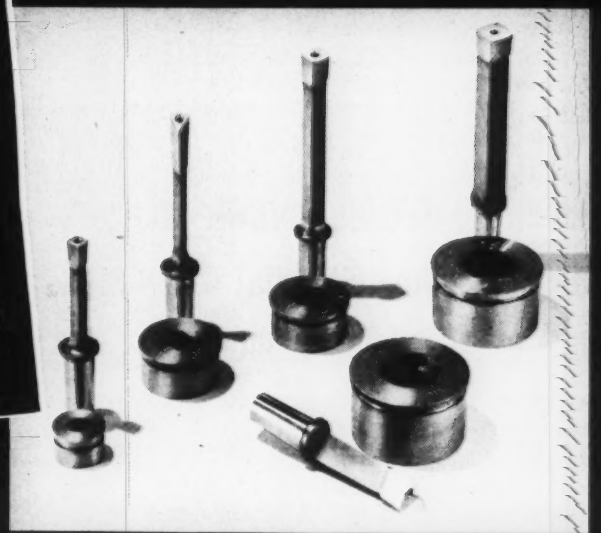
Temperature Test Chamber: Model TC-2A portable, self-contained unit is designed for production line tests of small products such as basic instruments, electronic subassemblies and mechanical components. Anticipator type thermostat provides accurate temperature control. Design incorporates three-heat selection switch, welded aluminum construction and glass fiber insulation. Statham Development Corp., Los *Angeles, Calif.*

Gear Checker: Red Ring Model SIC 24-in. gear checker inspects spur gears up to 25½ in. OD and splined parts for accuracy of tooth size, spacing, eccentricity and parallelism. The machine accommodates spur gears and splined parts up to 11⅜ in. between centers. Slotted table surface positions the various checking units in straight line and right angle locations. Interchangeable heads are provided for checking eccentricity and size combination, and tooth-to-tooth spacing. Parallelism accuracy of each side of a spur gear or spline tooth is checked by a double-indicator head unit mounted in front of the part being checked. Eccentricity and size are checked by a unit at the rear of the part being checked. Tooth-to-tooth spacing is measured by removing the eccentricity and size unit and adding a tooth-spacing head. The machine occupies a floor space of 60 x 51 in. *National Broach & Machine Co., Detroit.*

What every designer should know about THE ART OF GENERATING







Generating offers designers many advantages in producing an almost unlimited variety of contours. Produced by the relative motions of points, lines, or surfaces, all generated profiles are combinations of two basic surfaces: curved and straight.

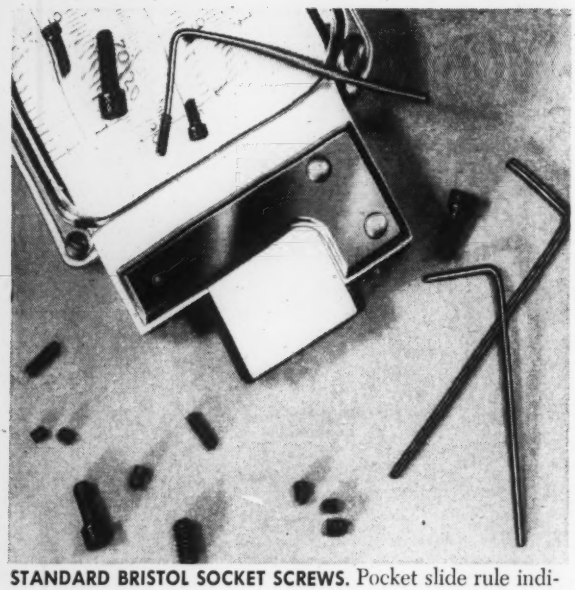
Generating with a reciprocating cutter on the Fellows Gear Shaper is a low-cost method of producing a wide range of symmetrical or irregular contours, either internal or external. Gear Shaper versatility provides a choice of generating techniques—employing a cutter form conjugate to work shape, introducing a variable movement between cutter and work, or a combination of both methods.

Shown above are some trim dies and the cutters used to generate them: three-sided cutters generate the square holes and four-sided cutters the hexagonal holes. Cutter sides are curved surfaces conjugate to the straight surfaces on the dies. The drawing shows the steps in generating. A special bed tilting mechanism in the Gear Shapers provides a simple adjustment for the required taper angle on the dies.

Many other examples of interest to designers are shown in the booklet, "The Art of Generating with a Reciprocating Tool." Just write any Fellows Office.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 319 Fisher Building, Detroit 2
5835 West North Avenue, Chicago 39
2206 Empire State Building, New York 1
6214 West Manchester Avenue, Los Angeles 45

THE PRECISION LINE **Fellows** *Gear Production Equipment*



STANDARD BRISTOL SOCKET SCREWS. Pocket slide rule indicates size.

Miniature socket screws for electronic equipment, instruments, and other small components

At Bristol we're old hands at precision instrument making—know what the problems are.

And we're also specialists in tiny, socket set and cap screws. They're standard at Bristol in sizes from No. 0 wire up to 1 inch in both hex and Bristol's Multiple-Spline socket in alloy and stainless steel.

Precision socket screws have been a Bristol product since 1913. And we've been turning out miniature socket screws by the millions since 1950. In fact we originated the famous Bristol Multiple-Spline socket.

Bristol Multiple-Spline socket screws can be wrenched up tighter and hold tighter than other socket screw types. Gear-like teeth in the multiple-spline socket transform all internal wrenching force into rotary power and protect tiny thin-walled screws against stripped sockets.

Today's automatic and semi-automatic production techniques pose no problem for Bristol's socket screws. They're used by the millions every year in instruments, computers, guided missiles and such competitive products as razors and cameras. And the new Bristol thru-broached socket screw for hopper feed is even more in line with the trend toward automation.

Find out all about Bristol socket screws. Ask your industrial distributor or write the Bristol Company direct. A.6.1A

Precision Socket Screw Manufacturers Since 1913

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½".

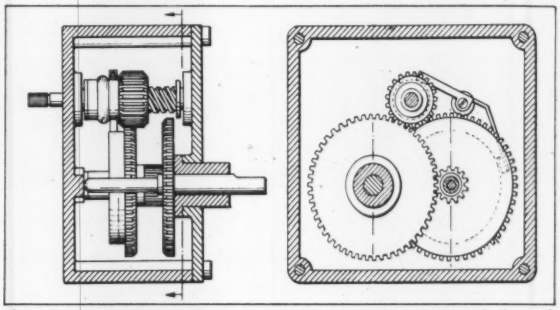
THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

—ITEM 661—

NOTEWORTHY Patents

Two-Speed Gear Transmission

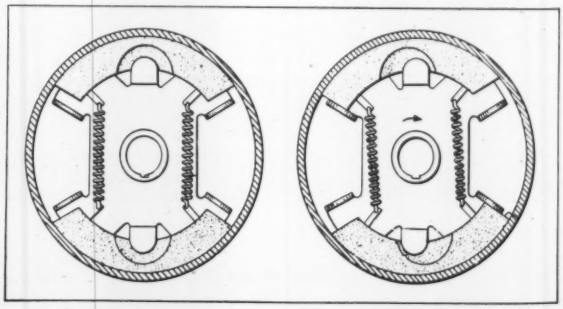
Reversal of input rotation in a gear box design changes the output speed but not the direction of rotation. A section of the input shaft has external screw threads and carries a nut member to which a pinion gear is integrally mounted. As the direction of input rotation changes, the nut and pinion travel back and forth between two extreme positions. In one position, the pinion meshes with a gear mounted to the output shaft. In the other position, the pinion



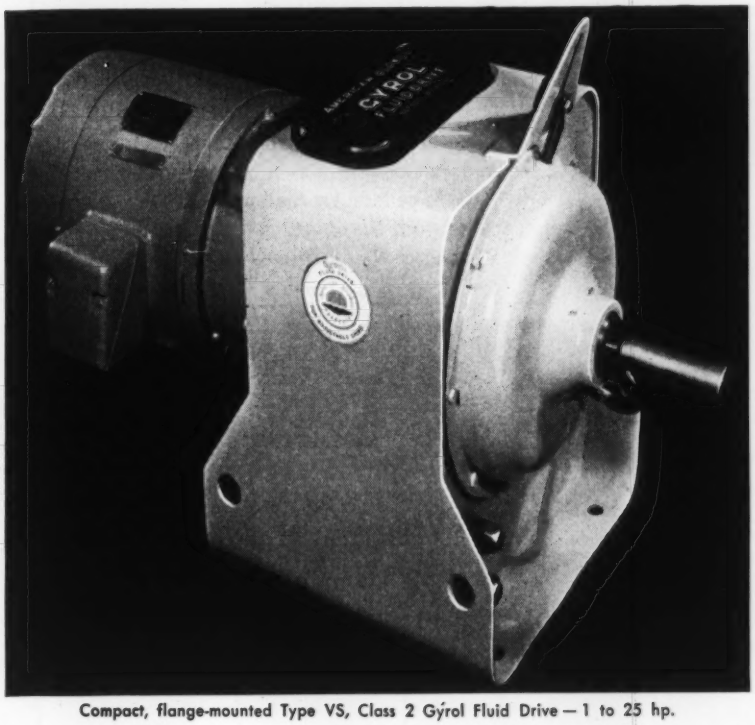
drives the output gear through reduction gears in a countershaft arrangement. Direction of rotation of the output shaft remains the same for both positions, and directions of rotation, of the pinion. In addition, movement of the nut along the shaft actuates a lever brake mechanism which stops rotation of the countershaft and output gears to minimize "clashing" as the pinion moves into meshing position. *Patent* 2,718,161 *assigned to Bendix Aviation Corp. by Donald O. Nelson and Birt G. Blackman.*

Centrifugal Clutch

A one-piece sheet-metal stamping serves as the basic power transmitting element in a clutch unit designed to engage automatically at a predetermined speed. Mounted to the driveshaft, a stamped spider member carries two molded friction shoes held loosely in place by guide tabs and a tension spring arrangement. As the drive shaft rotates, the shoes move



Why you should include Gýrol Fluid Drives in your plans for automation



Compact, flange-mounted Type VS, Class 2 Gýrol Fluid Drive — 1 to 25 hp.

For one thing, Gýrol Fluid Drives provide adjustable, *stepless* speed control of driven machinery, using *standard*, constant-speed motors — without complicated electric circuits or starting devices.

Adaptable to remote, manual, or automatic speed control, Gýrol Fluid Drives are compact, self-contained units — requiring only the conventional flexible-coupling connections to the motor and load. They provide complete shock absorption, are easy to install in a variety of arrangements of driving to driven machinery. Why not call our nearest branch for full details today?

Typical Applications

PUMPS, AGITATORS, MIXERS

CONVEYORS, CABLE & ROPE MACHINERY

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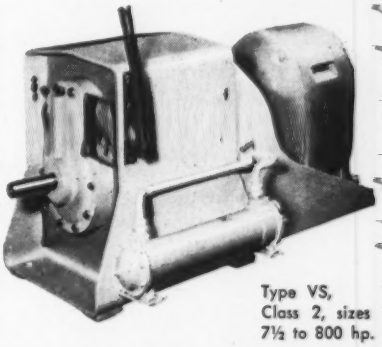
CENTRIFUGAL COMPRESSORS

PAPER AND PRINTING MACHINERY

TEXTILE MACHINERY

Complete range of sizes — 1 hp to 12,000 hp

The Gýrol Fluid Drive line includes a complete range of sizes, from 1 to 12,000 hp. All save power through lower horsepower requirements. A minimum number of wear points cuts maintenance. And, because Gýrol Fluid Drives bring about reduced speeds and pressures, driven equipment lasts longer.



Type VS, Class 2, sizes 7½ to 800 hp.

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—ITEM 662—

For More Information Circle Item Number on Yellow Card—page 19

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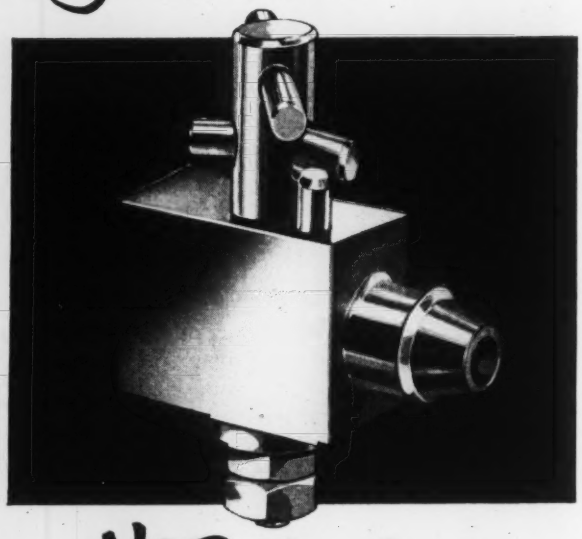
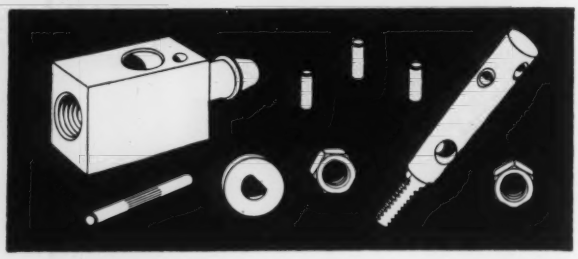


...NOT the Parts



WESTERN supplies the whole assembly... saves you time money and headaches

The stainless steel assembly shown here is typical of mass-produced precision assemblies you can get from WESTERN. You need just one purchase order, and you get the plus advantage of centralized responsibility.

WESTERN supplies experienced engineering counsel plus the finest production facilities for the manufacture of precision assemblies and screw machine parts—from wire size to 4¾" round. We do the *whole* job including all finishing operations—heat-treating, grinding and pentrating.

For fast delivery, precision quality and low cost put WESTERN on your production team.

Send us your blueprints for quotations today.

The Western Automatic Machine Screw Company

division of Standard Screw Company

383 Woodland Ave., Elyria, Ohio

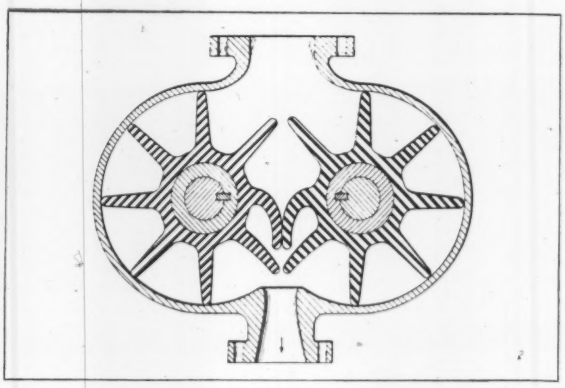
Precision Parts and Assemblies Since 1873

Noteworthy Patents

outward under centrifugal force to overcome the resisting spring action and engage a drum on the driven member. Frictional contact of the shoes and drum causes the shoes to shift sideways on the spider, engaging the end faces with lugs on the stamping to provide a positive drive connection. Speed of engagement can be readily adjusted to meet different application requirements by varying the tension spring size to provide different force characteristics. *Patent 2,718,924 assigned to Fairbanks, Morse & Co., by Werner E. Armstrong.*

Positive Displacement Pump

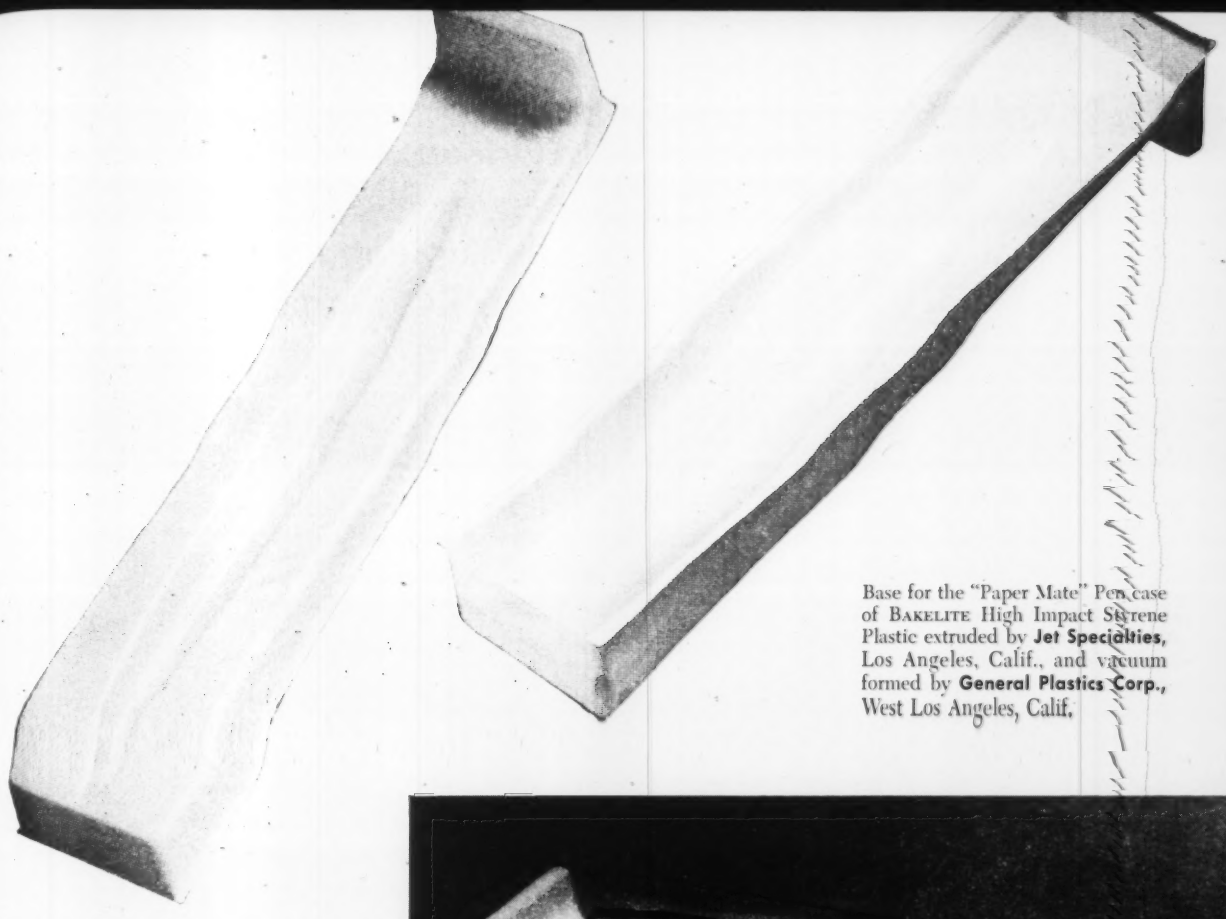
Dual synchronized impellers increase operating speed and capacity in a flexible-vane pump construction. The impellers are mounted so that the center distance between the shafts is less than impeller diameter. Flexing of the blades, which overlap and engage



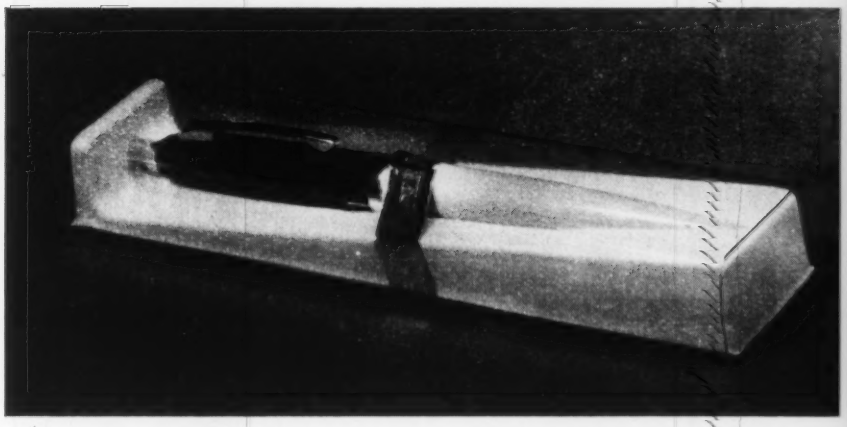
as they come together between the shafts, aids the discharge action. The impellers are driven in opposite directions through gears, mounted to the end of each shaft, which are constantly in mesh and synchronize the action of the blades. *Patent 2,719,001 assigned to Kiekhaefer Corp. by Carl Knuth.*

Adjustable-pitch sheave design for single and multiple V-belt drives permits effective pitch diameter to be varied without shifting position of centers of belt grooves. Locking of pitch adjustments is accomplished through a split hub which expands to grip the sheave bores securely in position and also serves as the shaft mounting member. *Patent 2,718,155 assigned to Dodge Mfg. Corp. by David Firth.*

Overrunning clutch for application under fluctuating angular speed conditions controls engagement and disengagement through a pawl and ratchet mechanism. Clicking of the pawl during overrunning is eliminated by a torsion spring and rubber block assembly which minimizes separation of the pawl and ratchet teeth and cushions shock due to re-engagement. *Patent 2,719,619, assigned to Deere Mfg. Co. by Marcus E. McClellan and Arnold B. Skromme.*



Base for the "Paper Mate" Pen case of BAKELITE High Impact Styrene Plastic extruded by **Jet Specialties,** Los Angeles, Calif., and vacuum formed by **General Plastics Corp.,** West Los Angeles, Calif.



"Paper Mate" selects BAKELITE Brand Impact Styrene for

Eye-catching display package

There are three important advantages for the Paper Mate Pen Company in this attractive container with base fabricated from Impact Styrene. It's an eye-appealing display that stimulates impulse buying. It's a sturdy package that keeps the pen fresh-looking and salable. And, the base is produced fast and at low cost by vacuum forming from flat extruded sheets of BAKELITE Impact Styrene, giving good gloss without costly finishing operations.

Your package, product or display may call for this plastic or one of many others; vinyls, phenolics, polyethylenes, styrenes, polyesters or epoxies. The best way to decide is to come to Bakelite Company where you find the greatest variety and the largest resources keyed to your needs. Write Dept. QR-103

BAKELITE BRAND PLASTICS

See BAKELITE's exhibit, booths #809, 813, 817, 825, National Plastics Exposition, June 11-15, 1956, New York Coliseum, New York

BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.

The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

NEW! Explosion-Proof MOTORS

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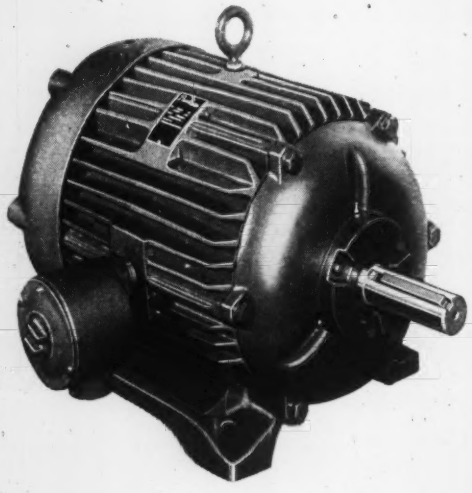

The new Peerless explosion-proof motor is Underwriters' approved for refineries, gasoline bulk plants, paint factories, grain elevators and other Class I and II hazardous locations where explosive vapors, fumes or dust exist. Single phase and polyphase designs range in size from 1 HP to 30 HP. Motors have ball-bearing construction. They are cooled by air drawn across the motor toward the driven machine by an external fan. Heat generated by the driven machine is not drawn across the motor. Our engineers, working with your engineers, can design any special mountings required to meet your application. Submit your requirements to Peerless. We'll help you select the explosion-proof motor that powers your equipment best.

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—ITEM 665—

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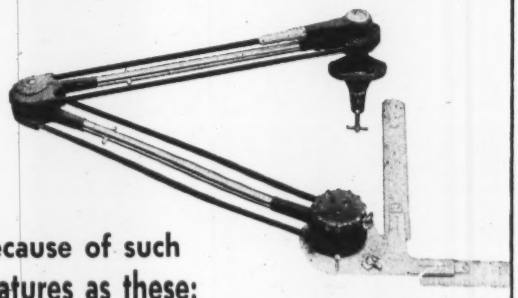

because of such features as these:

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Resilient scale chucks to insure firm grip.
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VEMCO Versatilt provides easy floating motion on tilted boards.

VEMCO

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—ITEM 666—

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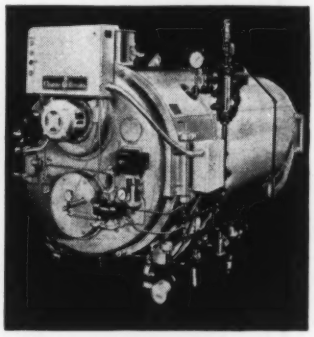

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SICON is easy to apply—one sprayed on coat does the job. It dries fast, and protects the surface for the life of the unit. If your product generates sustained heat you need SICON, *the finish that has stood the test of heat and time.* Write today! Dept. E-9

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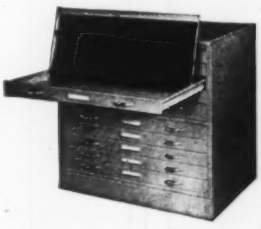
—ITEM 667—

MAYLINE

MAYLINE Steel Plan Files Meet Specifications

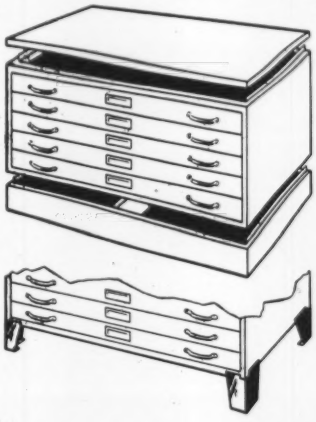


Mayline Steel Blue Print Files meet present rigid government specifications, and in accordance with those specifications, the 5-drawer units, caps, and bases stack and intermember.

Additional features are described in Folders S-20 and S-5. Have your dealer give you more details and price. He can promise you prompt delivery.

MAYLINE

MAYLINE



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Sheboygan, Wisconsin

MAYLINE

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- keep your production line going smoothly without shut-downs
- reduce rejects, hand adjustments or other supervisory attention
- provide you with precise gearing for any purpose whatever
- and do it with a strict adherence to safe engineering economy

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—ITEM 669—

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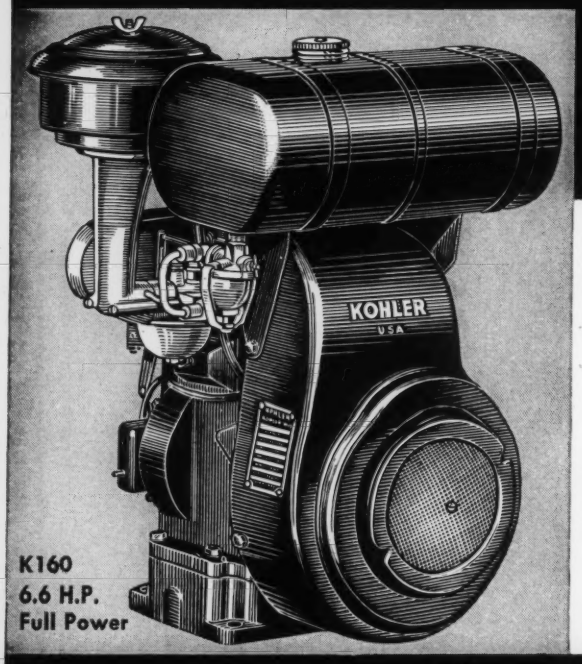
Erie, Pennsylvania

Representatives in Principal Cities

—ITEM 670—

For More Information Circle Item Number on Yellow Card—page 19



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6.6 H.P.
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- More Power
- Longer Life

Easy Starting

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K160	3.6 to 6.6 H.P.
K330	7 to 11.8 H.P.
K660	12 to 26 H.P.

Kohler Co., Kohler, Wisconsin
Established 1873

KOHLER OF KOHLER

PLUMBING FIXTURES • HEATING EQUIPMENT • ELECTRIC PLANTS
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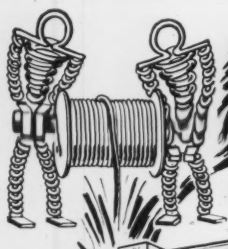
—ITEM 671—



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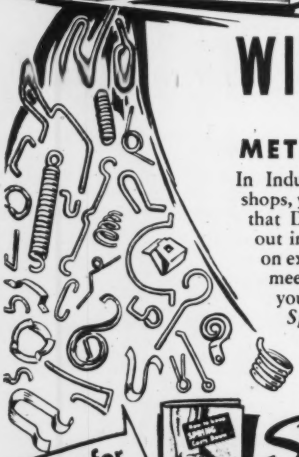
DUDEK & BOCK
THE Leader!



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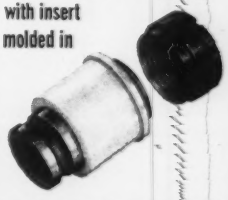

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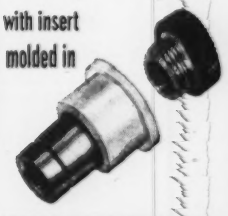

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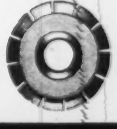

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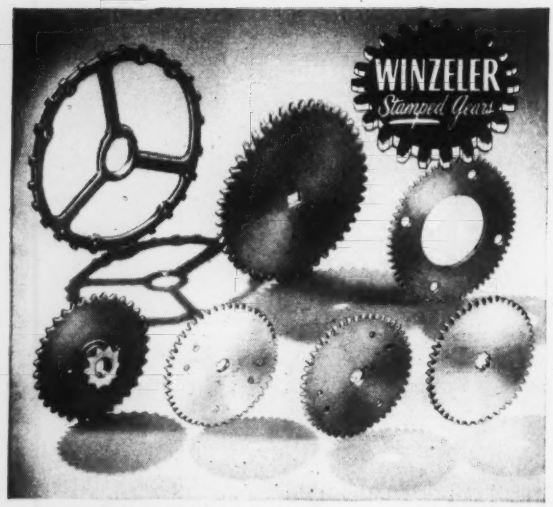

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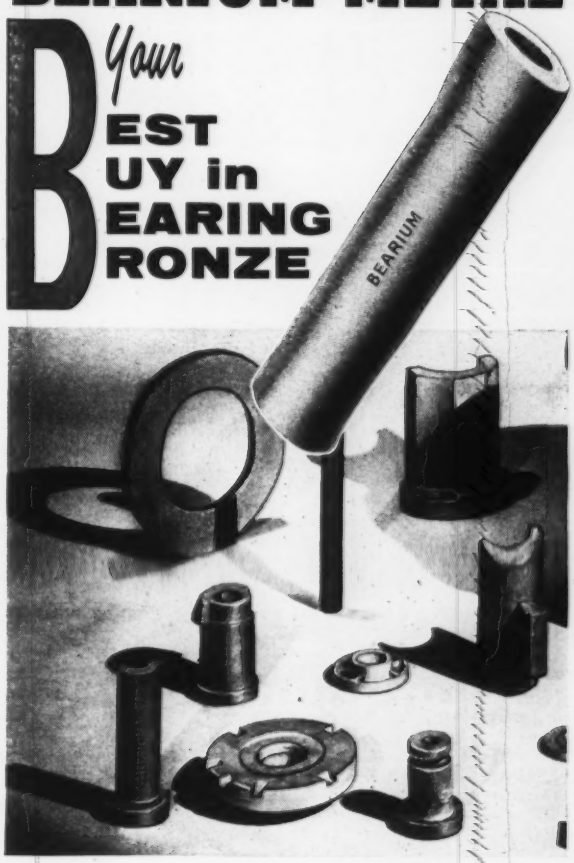

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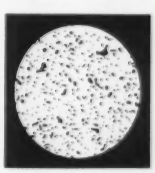
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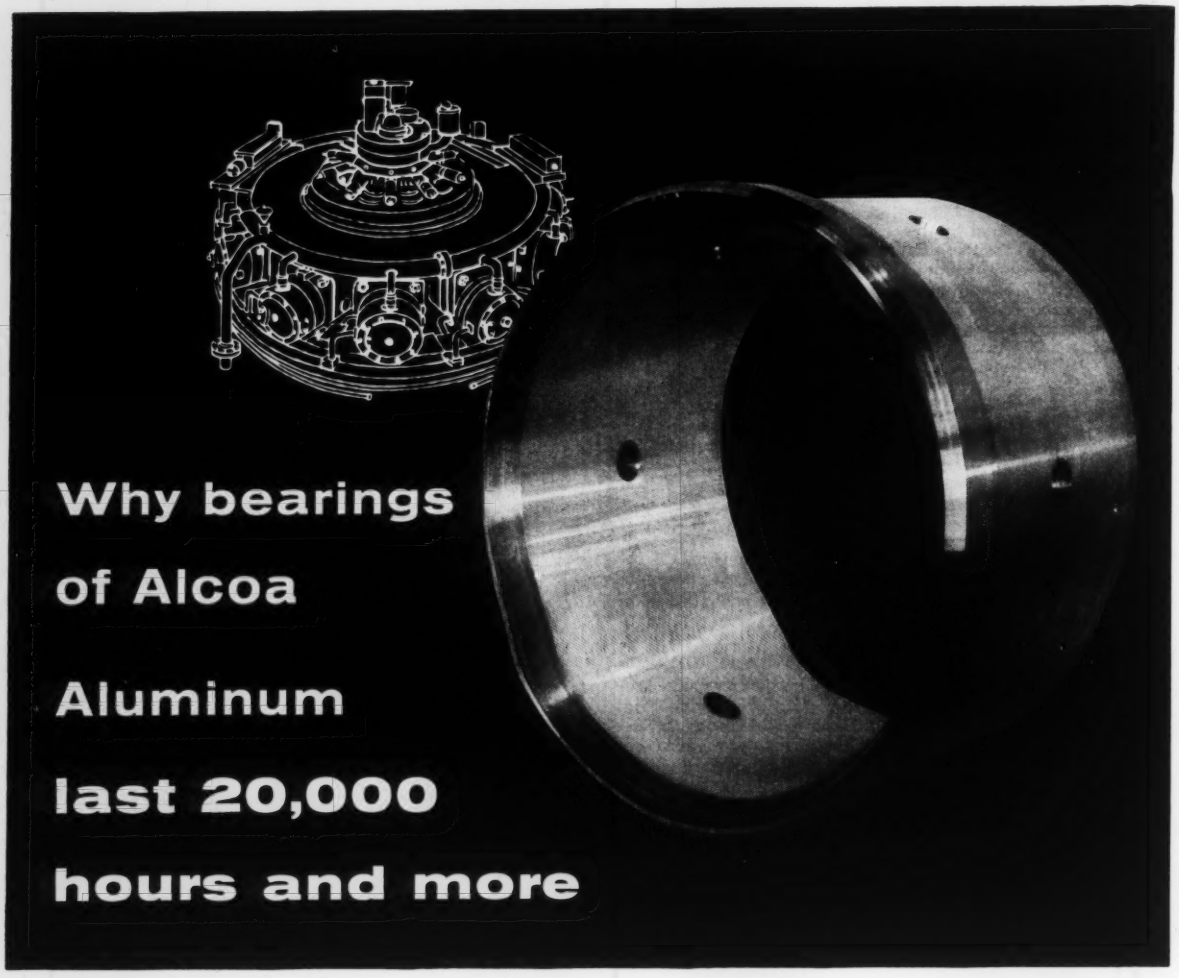

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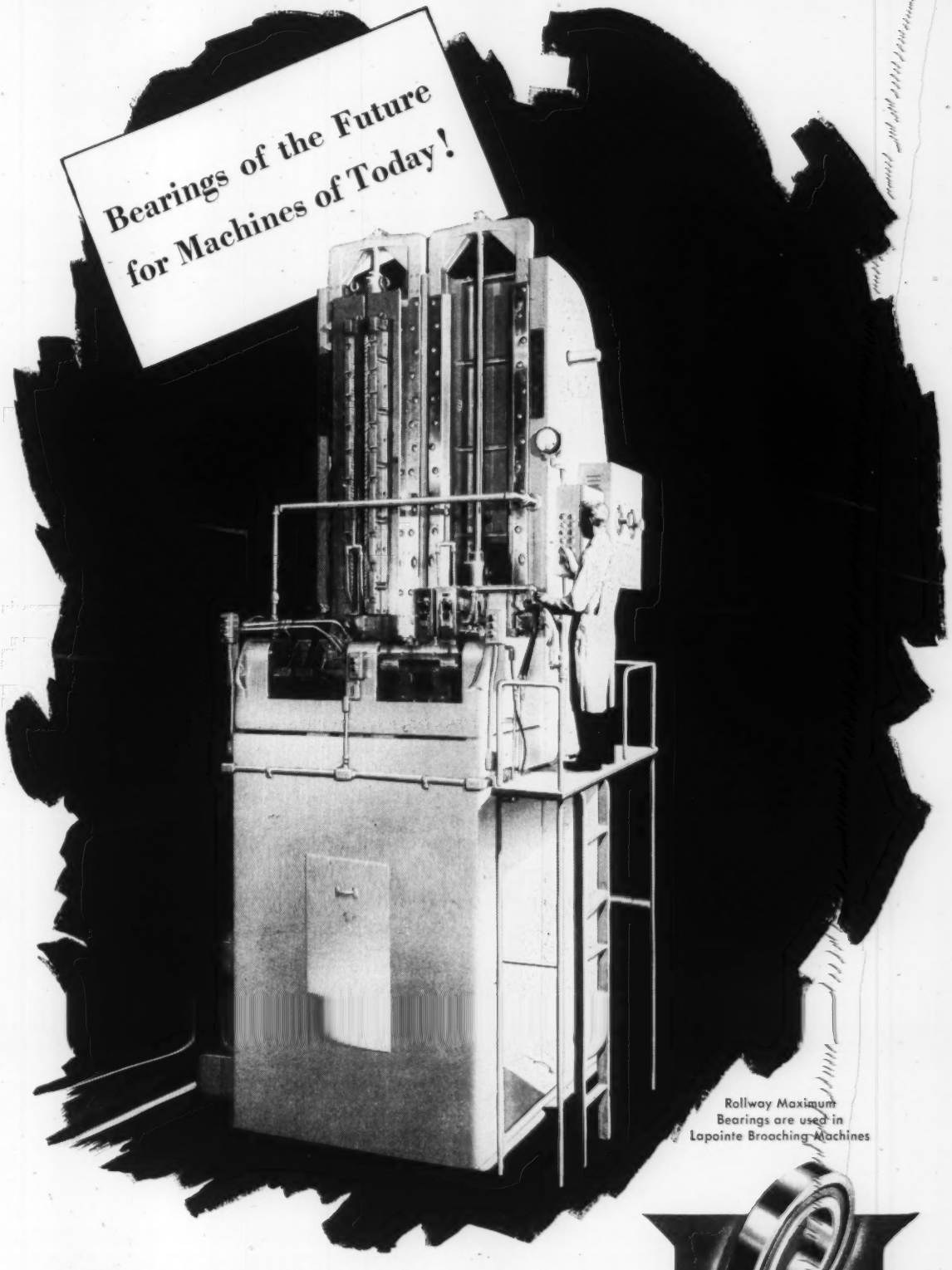
Bearings of the Future for Machines of Today!



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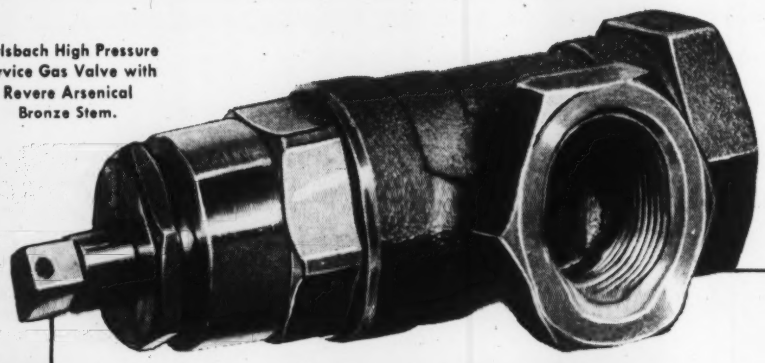

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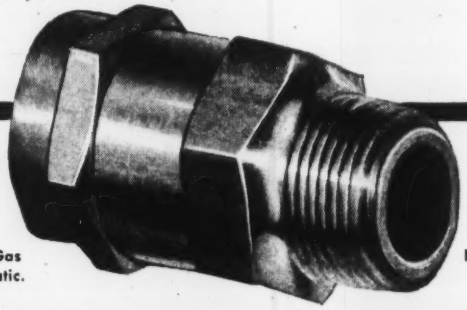

Welsbach Temperature-Pressure Relief Valve.

Welsbach Emergency Gas Shut-Off Valve, automatic.

Pressure Relief Valve for water heaters.

—ITEM 683—

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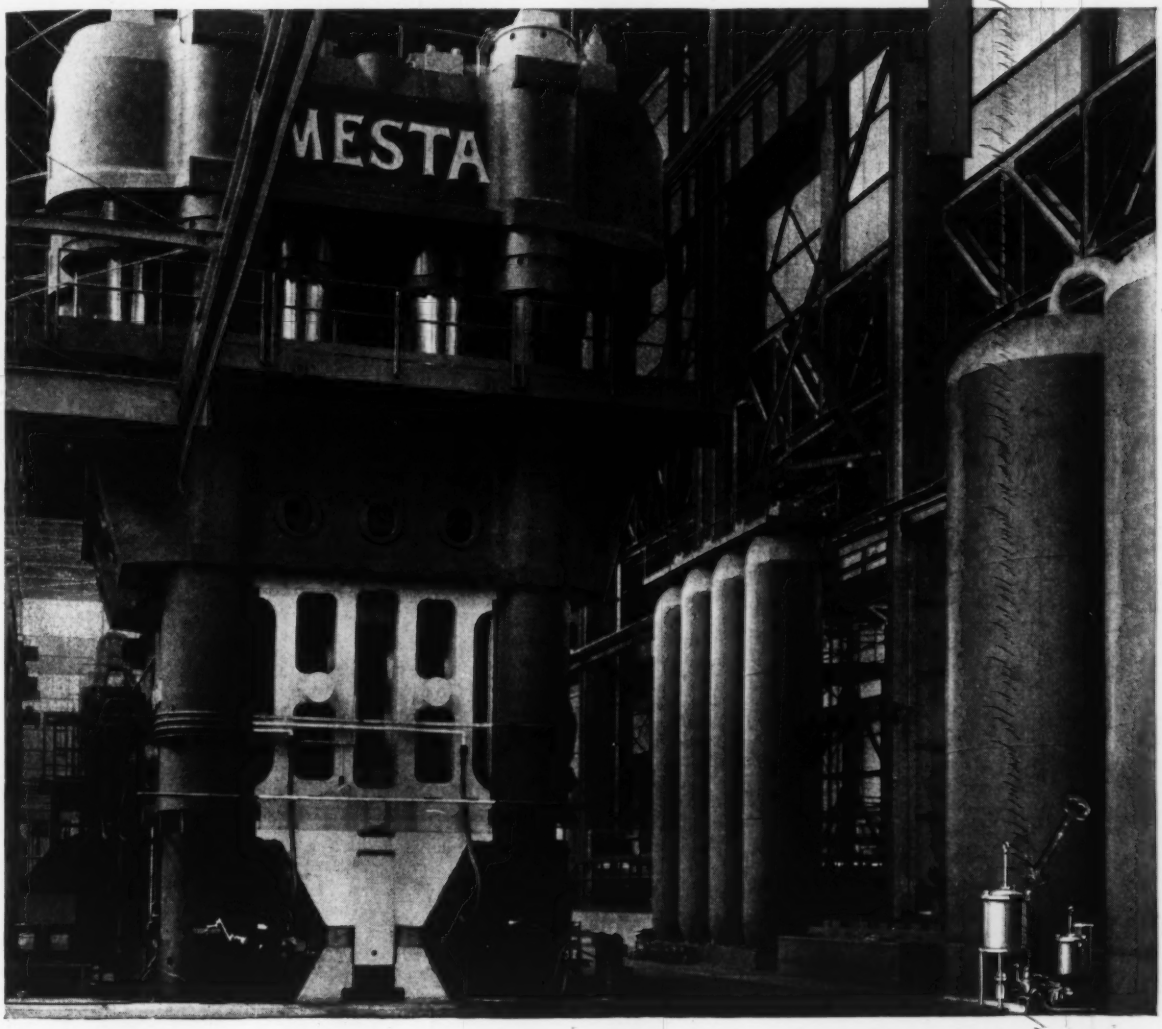

KEYS TO ADEQUATE LUBRICATION— Wherever you see the sign of Farval—the familiar central pumping station, valve manifolds, dual lubricant lines—you know a machine is being properly lubricated.

The Farval central stations, visible at lower right, serve this 50,000-ton forging press.

Pioneer in lubricating presses of all sizes, Farval was chosen to lubricate this 50,000-ton Mesta Press installed recently in the Cleveland works of the Aluminum Company of America.

With equipment of this size, the importance of a lubrication system increases many fold. It *must* be adequate. It *must* be dependable. It *must* function without shutdown. Farval fills the bill—delivering oil or grease unfailingly, in exact amounts required whenever needed. The press is protected, man hours and lubricant saved, guesswork lubrication eliminated, steady production maintained.

You will find Farval representatives ready to serve you in all major industrial centers. See how Farval pays for itself many times over—write for Bulletin 26-R. The Farval Corp., 3287 E. 80th St., Cleveland 4, O.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing.
In Canada: Peacock Brothers Limited.

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For More Information Circle Item Number on Yellow Card—page 19